DOCTOR OF PHILOSOPHY

Investigating the Relationship Between the Culture of Construction Project-Based Organisations and the Implementation of Building Information Modelling (BIM)

Hossain, Mohammad Kamal

Award date:
2015

INVESTIGATING THE RELATIONSHIP BETWEEN THE CULTURE OF CONSTRUCTION PROJECT-BASED ORGANISATIONS AND THE IMPLEMENTATION OF BUILDING INFORMATION MODELLING (BIM)

By

Mohammad Kamal Hossain

A Thesis Submitted to the University of Dundee in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

School of Science and Engineering, University of Dundee

Dundee, Scotland, UK.

February, 2015

DECLARATION

I, Mohammad Kamal Hossain, hereby declare that I am the author of this thesis; that the work of which this thesis is a record has been done by myself; and that it has not previously been accepted for a higher degree.

Signed: ___________________________ Date: _________________

(Mohammad Kamal Hossain)

CERTIFICATE

We certify that Mohammad Kamal Hossain has worked the equivalent of nine terms on this research, and that the conditions of the relevant ordinance and regulations have been fulfilled.

Signed: ___________________________ Date: ______________

(Andy Munns)

ABSTRACT

The implementation of Building Information Modelling (BIM) is a consequence of the mounting pressure for improving efficiency in the construction project delivery process. It captures versatile benefits, such as extensive use of information in a building project, improvement in efficiency in the project delivery process, and better management of information for a project during both delivery and operation phases. Nevertheless, a number of issues are raised during the implementation of BIM, which ranges from technical complexity, legal concerns, and up to the cultural barriers. The issues raised in a BIM project have a significant impact on the success of the implementation of BIM. On the other hand, the implementation of BIM has substantial effects on the culture of the construction project-based organisations. The aim of this research is to investigate the relationship between the culture of the project-based organisations and the implementation of BIM, and the interactions that take place among the participants within a project supply chain. The investigation has been carried out by different approaches, i.e. Grounded Theory (GT), regression analysis, and Competing Values Framework (CVF) analysis. Methodological and data triangulations have been performed to validate the findings in the research.

In this study, it has been found that the leadership in a BIM project has an obvious influence on the integral parts of BIM. The elements of BIM, i.e. BIM implementation plan and protocol, value proposition, capacity building programmes, and data exchanges and accessibilities within a particular project, build the culture of the project-based organisation. It also adds value to the project. It is also revealed that the culture in a BIM project can be perceived in terms of the coordinations and integrations within the project delivery process performed by the people and the interactions between themselves. The findings in this research further indicate that the essential parts of BIM are the determinants of the outcomes in a project regarding of collaboration and project value. The overall results of the study propose an understanding on the various elements of BIM and their associations with the project outcomes which are achieved through the implementation of BIM. This will provide necessary guidelines to implement BIM successfully in a construction project.

DEDICATION

This research work is dedicated to Mr. M Alauddin. We lost him during my study. He has left noticeable contributions in the construction industry of Bangladesh by leading a number of public construction projects as a top level entrepreneur.

ACKNOWLEDGEMENTS

Foremost, I would like to thank my principle supervisor Mr. Andy Munns, Associate Dean of Learning and Teaching, School of Science and Engineering, for providing me with the opportunity to complete my PhD thesis at the University of Dundee. I cordially want to thank him, whose supports and guidance made my research work possible. Especially, during the low productive time periods and various difficult moments, his guidance and supports brought me back to the right track to carry out the research work. He has been actively involved in my work and has always been available to advise me. I am very grateful for his patience, motivation, enthusiasm, and immense knowledge in construction project management that, taken together, make him a great mentor.

Special thanks to my second supervisor Dr. Robert Makie for providing me necessary supports from earlier and critical periods during my research. Especially, I like to thank him for allocating me an appropriate advisor in an unexpected circumstance which was a crucial event for me. I want to thank my previous advisor Dr. Motiar Rahman who opened the opportunity for me to study in the university and guided me to commence the research work. During the initial stage of my research, he instructed me and provided essential supports to enter into the world of research. I cannot but give thanks to Mr. David Husband for helping me over the years in various occasions for IT supports and troubleshooting my PC problems. His supports enabled me smooth learning and released my agony at different crucial moments.

I would like to thank Professor Stephen Olu Ogunlana, School of Built Environment, Heriot Watt University, Edinburgh, UK, for his continuous encouragement and supports for more than a decade. I recalled him on various occasions while I had any mental crisis. Especially, he gave me necessary suggestions before and during my study in Dundee.

I would like to thank a number of people in the construction industry from different corners of the world who helped me by providing their valuable time during the data collection period. Special thanks to Cara Onesti, Business Development Manager at Laing O'Rourke, and Ahbar Chowdhury, Principal Engineer at Hyder Consulting, for giving me the opportunity to collect data and to motivate the people to participate in the research. I cannot but give thanks, Dr.

Mesbahuddin Chowdhury, Dr. M A Rouf, Dr. Azizul Moqsud, Dr. Kamal Hossain, and Barrister Syed M Marfat for providing me necessary supports at difficult moments during the research activities.

For the non-scientific side of my thesis, I particularly want to thank my partner Mrs. Israt Jahan Ripa for sharing her life with me while I was adopting a way of living with research work for four years. Her hard work, patience, and supporting activities drive me to overcome difficulties and make her an appropriate key holder of the family. During this long period, she and our son K.S.B.K Rusho shared both pleasant and unpleasant moments of consequences. I would like to give thanks to Dr. Ferdous Jahan and Mr. Abdul Awaal for providing us necessary supports over the years of study.

I like to give special thanks to Dr. Rafiqual Islam and his wife Mrs. Jarin Islam, Engr. M M R Hasan and his wife Mrs. Zakeya Sultana, and Barrister Shahidullah Chowdhury and his wife Mrs. Rahita Khaleque for providing us enormous supports during the period of stay in the United Kingdom. Additionally, the delicious meals prepared at their homes at various occasions highly impressed me. Finally, I thank my friends and relatives across the globe for their faith and support during the study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1 Background

Many reports have identified that the construction industry is underperformed and clients are not getting optimum value of the projects (Latham, 1994; Egan, 1998; 2002; Fernie *et al.*, 2006; CO, 2011). This issue stimulated the mounting pressure for improving efficiency in the construction project delivery process (Jackson, 2000; Elmualim, 2008). The long-term burden of adversarial relationship, process fragmentation, and ineffective planning lead to generation of waste and inefficiency in the delivery process (Fleming and Koppelman, 1996). In consequence, it hinders the cost reduction, productivity, innovations, industrial growth, new opportunity creation, and entrepreneurs' interest on investment. Furthermore, staying at rear on the race, the construction industry fails to enjoy the advantage of rapid developing technology (Cain, 2003). Efforts have been spent for the integration of project delivery process for very earlier which is continued with a series of public reports. For instance, in 1944, in the UK, The Simon Report 'The Placing and Management of Building Contracts' was prepared by the Simon Committee to address the issues in management of building contracts (ICE, 2016). This report was the first report to identify the obstacles on project delivery process in a modern concept. Following many other reports such as Latham (1994), Egan (1998), the latest movement is the UK Construction Strategy (2011). Thus, implementation of latest technology to improve project delivery process by identifying and minimising discrepancies is getting core attention in the construction industry across the globe.

In addition to the discrepancies, unpredictable demand of infrastructures made the construction design and delivery process critical (Ilozor and Kelly, 2012). Efforts have been spent on finding out the solution to improve efficiency in the construction project delivery process. The major focus of the initiatives was to attain a collaborative practice in the project delivery process. Various collaborative working arrangements (CWAs) such as Partnering, Private Financing Initiatives (PFI), and Integrated Project Delivery (IPD) were prescribed by a series of industry reports to minimise waste and address inefficiencies (e.g. Latham, 1994;

Egan, 19998 and 2002; HMSO, 2008). According to American Institute of Architects (AIA, 2007b), IPD, as one of the CWAs, is a tuned approach of project delivery process. In contrast, it offers solution up to the end of construction stage without talking into account of the whole life cycle of a project and integration of information flow among the participants connected to a specific project (Glick and Guggemos, 2009). Apart from this, there is a lack of collaborative practice in the construction industry; particularly, among the small and medium sizes enterprises (SMEs) (Khalfan and McDermott, 2007). As a result, there is an existing trend of declining productivity, and in consequence, the concern about waste and inefficiencies has been reinforced (Arayici *et al.*, 2011). As such, the construction industry spends continuous efforts to enhance efficiency through attaining a fully collaborative process throughout the whole lifecycle of the project. The latest movement on this agenda is the implementation of Building Information Modelling (BIM).

It has been emphasised by both clients and suppliers that the construction delivery process needs to refine in terms of integrated teamwork, seamless information flow, and long-term relationship among the supply chain stakeholders (CO, 2011). To achieve these objectives, a fundamental change in the project delivery process is essential that necessitates an effective transformational scheme. BIM allows the essential changes in project delivery process by applying new technology in all spectrums of a building project such as design, construction and operations of a building (Rosenberg, 2007; Arayici *et al.*, 2011; Malleson, 2012). It works as a unifier of people, information, process and technology (Hossain *et al.*, 2013). Beyond the capability of IPD, BIM demonstrates long-term benefits as the whole life cycle is embraced by this process. It is the process where participants collaborate in a shared platform and environment.

The core proposition of BIM is to attain a fully collaborative practice in the project supply chain and to achieve optimum project value (Philp, 2012). Nevertheless, the degree of potential benefits of BIM relies upon the level of integration taking place among the key players in the process (Andre, 2011). Also, the multi-skilled team requires to integrate by developing and sharing new ideas, tools, and innovations (Khalfan and McDermott, 2007; NBS, 2011). However, Rosenberg (2007) and Udom (2012) agree that with the progress of the process of modelling, relationships between the parties become more closed, border of responsibilities becomes blurred, and more critical issues are raised. These issues hinder frequent interactions between the parties. Furthermore, it is difficult to flourish inter-organisational collaboration in such a team because each party efforts to achieve their own objectives and avoid their economic loss (Latham, 1994).

As higher level of inter-dependency exists among the parties of the BIM project team (Clough *et al.*, 2008), the success of teamwork depends on the cooperation of other parties. These unique characteristics and higher inter-dependency of a BIM project influence the existing culture of the project-based organisations (Hossain *et al.*, 2013). On the other hand, the existing culture has substantial impact on the success of the implementation of BIM (Hossain and Munns, 2015). Hence, a critical relationship exists between organisational culture and the operation of BIM in the project-based organisations. The overall purpose of this research is to identify the relationship between the culture of the construction project-based organisations and operation of BIM within the project delivery process including the behavioural approach and interactions taken place among participants while operating BIM.

1.2 Identification of Gap, and Need for Further Study

Many authors mention that implementation of BIM is often hindered by the number of barriers in various aspects (Rosenberg, 2007; Yan and Demian, 2008; Andre, 2011; Azhar *et al.*, 2011). As the implementation of BIM is still an ongoing process within the industry, proven guidelines are still not available which will fit to a particular project. Sufficient study on the implementation of BIM is still an arguable issue. The Following are the gaps and industry requirements in terms of the implementation of BIM in the construction project delivery process:

a) Teamwork and collaboration in BIM-enabled project-based organisations

Construction projects are accomplished by project-based temporary organisations (i.e. project teams). In a construction project, representatives from multifunctional contract parties are gathered at the beginning of the project and work as a team (Davis *et al.*, 1992). However, team members are dispersed at the project closure (Akintoye *et al.*, 2000). Macmillan (2011) argues that to achieve the goal in a construction project, essential skills, knowledge and talents are harnessed effectively. Roma and Ogunlana (2009) further claim that alongside their own organisational objectives, culture and working practice of each contract party, the deployed individuals can have diverse origins, backgrounds, and cultures. As such, in a project-based organisation, inter-organisational teamwork is developed; which obviously differs from typical teamwork in a stable economic organisation or department (Fong and Lung, 2007).

The key attribute of the BIM project team (project-based organisation) is cross-functional and cross-cultural assembly which is embraced by leading-edge technology. The team is focused on a shared objective; whereas the individual organisational objectives of the contract parties remain behind. It is frequently argued that this kind of team is inevitably complex and often encourages adversarial culture due to lack of trust and cultural empathy (Harvey *et al.*, 1998; Steele and Murray, 2001). Besides, other influential factors which encourage adversarial culture are: communication difficulties, inappropriate planning and team direction, lack of loyalty and commitment, poor or wrong leadership, inappropriate recognition and reward provision, silo thinking, and social loafing (Mickan and Rodger, 2000; Parker, 2007; Kreitner and Cassidy, 2012). As BIM is a collaborative process, existing attributes of that culture may have negative impact on the success of the implementation of BIM, which need to be explored prior to taking necessary measures to foster the adoption of BIM.

b) Need a behavioural change within the project supply chain: the key challenge

The implementation of BIM involves a fundamental change in the way of working in the current project delivery process (Eastman *et al.*, 2011). Andre (2011) mentions that the successful adoption of BIM necessitates the team members to reach an agreement on using the technology and providing combined effort. Extant literature suggests that BIM creates a shared platform for all stakeholders to interact frequently, solve problems, and make decisions together (NBS, 2011; Redmond *et al.*, 2012). The shared platform is built up with common data repository and technical standards which will allow all the parties to work without any issues of interoperability and availability of information within a particular project. Philp (2012) asserts that by performing computer trials, team members can detect the conflicts between the building components and constructability challenges, and thereby mutually find the answers of the critical questions for the entire lifecycle of a project. This kind of feedback loop saves time and cost. However, to extract the best value through a collaborative process, BIM have to be implemented effectively (Ahmad *et al.*, 2012). A number of authors (Succar, 2009; Eastman *et al.*, 2011; Udom, 2012) suggest that implementation of BIM involves a fundamental change in the working procedure in the project delivery process. Such a procedural change is a cultural shift which involves behavioural change of the participants—the key challenge. Construction industry needs to overcome this frontline challenge to implement BIM effectively.

The potential benefits of BIM rely upon the level of integration takes place among the players in the modelling process (Philp, 2012; Udom, 2012). To achieve efficiency in BIM a project, a multi-skilled team needs to be integrated by developing and sharing new ideas, tools, and innovations (Egan, 2002; Khalfan and McDermott, 2007; Succar, 2009; NBS, 2011). Many authors mention that purchasing high-tech software and using it—does not mean the adoption of BIM as it will not create the desired value (Hardin, 2009; Gu and London, 2010). A fully functional integrated team is essential to embrace the whole fragmented process where the role of BIM is to be a ‘unifier’. For example, implementation of BIM in the Architecture, Engineering, and Construction (AEC) industry in the UK, insisted by the clients, involves both process and behavioural changes in every level of the business (Arayici *et al.*, 2011; Malleson, 2012). Bernstein and Pittman (2004) note that technology alone is not sufficient to adopt BIM. It has been argued that such a revolutionary move requires synergistic efforts by the multidisciplinary players (Dossick and Neff, 2010; Arayici *et al.*, 2012; CTGR, 2012). Hence, the willingness of the parties to adopt new generation of tools, their behaviour, and interactions between them, appear to be the significant factors for the successful implementation of BIM.

c) The modelling process involves new critical issues

Rosenberg (2007) asserts that simultaneously with the progress of modelling, data modification goes on, inter-organizational collaboration becomes more functionalised, participants’ roles remain changing, and interdisciplinary relationships become more established. However, at the same time, complexity of the processes is increased, distribution of responsibilities and risks become more blurred, and more difficult contractual issues are raised (Sebastian, 2010; Andre, 2011). It is often argued that this increasing dynamic complexity over time accelerates ineffective collaboration and blame culture in construction projects (Dossick and Neff, 2010).

In a transition period of the implementation of BIM, in a multifunctional team, people select their tools including various software packages and information communication technology (ICT) according to their own organisational technical and financial capabilities. Using the software or ICT facilities requires particular skills, infrastructure, and training. Parn *et al.* (2015) add that individual software packages have their particular purpose in different steps of the modelling process. As such, a modelling process involves a number of software and ICT facilities, which necessitate significant expenditure. However, expenditure on software and ICT is becoming an integral issue of the construction industry (Underwood and Khosrowshahi, 2012). Therefore, the construction industry needs to identify the necessary solution to overcome this issue.

In the complex working environment in BIM-enabled projects, there is no available practical guideline on particular issues such as responsibility of model development, errors, mistakes, and omissions in this contribution-based convergent design concept (Andre, 2011). Parties from various disciplines produce their own disciplinary information models and upload in a central repository. This data repository is shared by the parties involved within a supply chain. Also, the main model is produced by integration of various disciplinary models by different organisations. In such a process, undefined distribution of risk and reward causes knock down effect to the spirit of teamwork (Bernstein and Pittman, 2004; Rosenberg, 2007; Ashcraft, 2008). To functionalise this complex process effectively, understanding of relationship development and collaboration in BIM setting are essential. Further study is therefore required to explore the cultural elements which influence effective teamwork in a BIM-enabled project (Ilozor and Kelly, 2012).

Model related issues are the frontline obstructions in this open collaborative process (Ashcraft, 2008). Andre (2011) and Udom (2012) also assert that the issues which are often causing stress to the participants in this immature BIM environment are data copyright, intellectual property, i.e. ownership of data and model, confidentiality of data in a blended state, and signing documents. For example, the core team members such as architect, engineer, and contractor may want to own data as they are producing it. On the other hand, the owner wants to have it as they are paying for the job. The owner may have the intention to use the model in future. A copyright issue is raised in this case.

In a Building Information Model, shop drawings are prepared by the suppliers are fed or, plugged-in into the model for various purposes such as to develop the major model or clash detection; and, the drawings are printed from the model as produced reports. As the most state laws instruct architect and engineers to sign their own documents, they will be severely reluctant to sign the drawings that include the drawings which are not produced by them. These issues undermine the efficiency of integrated process. Thus, progressing with BIM involves more critical legal issues (Udom, 2012). Inter-organizational contractual arrangement or, flexibility in contract may solve these issues. Many authors add that along with the legal bindings, participants need to build trust, empathy, and tolerance to manage collaboration, communication, and decision making (Sebastian, 2010; Macmillan, 2011). The legislative gap between existing legal settings and practical implication demands further investigation to identify the impact on the practice in the construction project-based organisations due to the implementation of BIM.

d) *Implementation of BIM faces cultural barrier*

Participants in a BIM project use different kind of software packages and technical infrastructures depending on their requirements and abilities. According to Andre (2011), as BIM is a high-tech and collective approach of modelling, limited technical configuration and diversity of software may not allow desired interactions between the parts of the building model prepared by individual parties. Furthermore, the architects and engineers are habituated to work in their own process. The long-term habit of self-working-process pulls down the more experienced people or SMEs towards the traditional process from high-tech driven collaboration. Thus, existing culture and work practice in various organisations negatively impact on the successful implementation of BIM. Therefore, it is essential to find out the nature and extent of this kind of negative influencing factors to take necessary measures against these cultural barriers for implementing BIM.

> Culture in a traditional construction project-based organisation is comprised by different organisational culture (Roma and Ogunlana, 2009), where cultural conflicts often create a confrontational environment (Dossick and Neff, 2010). This situation ultimately leads to an adversarial culture in a construction project (Abeysekara and Lata, 2002; Cain, 2003; Macmillan, 2011). The adversarial culture is reinforced by the process fragmentations within the delivery process. Implementation of BIM is intended to eliminate process fragmentations and functional adversaries by overlapping the construction phases and enabling effective collaboration in the projects (Philp, 2012). Such a revolutionary move involves a fundamental change in working style (Succar, 2009; Eastman *et al.*, 2011), which is a massive cultural shift, from an adversarial culture to a collaborative culture. However, numerous authors argue that besides applying the latest technology like implementation of BIM requires combined effort of all the participants throughout the process (Hardin, 2009; Gu and London, 2010; Arayici *et al.*, 2011). Given that the development of the model depends on the contribution of the participants from diverse disciplines in a project (Rosenberg, 2007; Andre, 2011).

Although BIM appeared in the construction industry more than two decades, the adoption of BIM is still not significant within the industry (Bew and Underwood, 2009; Underwood and Isigdag, 2009; Malleson, 2012; NBS, 2014b; Dakhil and Alshawi, 2015). Hossain and Munns (2015) mention that despite the increasing awareness of BIM within the construction industry, BIM adoption is still behind the expectation, which is a major concern of the practitioners in the industry. The key reasons are the resistances against the change of the way of working as it influences the culture of the project-based organisations in the construction projects. These issues are raised from the existing culture of the multi-functional organisations involved in a project. Besides, organisational capabilities are related to the adoption process during this transition period. The overall scenario becomes critical because the implementation of BIM has an impact on the culture of project-based organisations and the existing culture of individual organisations have influence on the implementation of BIM. Therefore, the industry needs to uncover and address the issues to ensure successful implementation of BIM. First of all, it is one of the fundamental requirements to understand the cultural phenomena and the interactions among the participants within the project-based organisations in the new environment with BIM.

1.3 Research Questions

From the discussions made earlier, the major research questions raised are as follows:

1) What is the relationship between the culture of a construction project-based organisation and the implementation of BIM?

2) What are the interactions that take place among the participants in a construction project while operating BIM?

1.4 Aim and Objectives of the Research

The overall aim of this research is to identify cultural factors in the project-based organisations, and the relationships between the cultural factors and the implementation of BIM while operating BIM. To meet the key aim, the following specific objectives have been set:

1) to identify the critical relationships between the elements of culture and the operation of BIM in project-based organisations;
2) to assess the current state of culture in BIM-enabled projects;
3) to assess the success of the implementation of BIM;
4) to establish the impact of the implementation of BIM in the culture of the construction projects;
5) to identify the relationship between the individuals' company culture and project culture in a BIM project.

1.5 Scope of the Study

The scope of the research study is as follows-

a) Procurement practices in the construction industry;
b) Building Information Modelling (BIM);
c) Organisational culture in BIM projects;
d) Integrated Project Delivery;
e) Competing Values Framework;

f) Hermeneutic phenomenology;
g) Grounded Theory;
h) Regression analysis;
i) Projects are considered in a global perspective. Projects ranges from various sizes and types such as hospitals, school, hydraulic structure, hotel, laboratory, and student accommodation
j) Types of contract in the projects include PFI, design-build, and partnering.

1.6 Chapter Reviews

To achieve the objectives this research has been carried out through a number of activities. The activities and findings from this research are explicated in following different chapters:

Chapter 2

This chapter describes review on extant literature related to the implementation of BIM in the construction industry. It is identified that the underperformance of the construction industry came into notice on several times and efforts have been spent. Implementation of BIM is a time demanding issue in the construction industry to improve the construction project delivery process. The implementation of BIM offers versatile benefits in a project by considering the whole life cycle of a project. The implementation process of BIM involves application of a new generation tools which promises change in behaviour and working styles of the people within the industry, which demands a cultural shift. However, this cultural change is often hindered by a number of barriers ranging from technical, cultural, legal, and organisational. BIM allows the cultural change of project-based organisations through its integral elements and activities. A number of elements that build the culture of a BIM-enabled project-based organisation are leadership, teamwork, coordination between the parties, and interactions between the parties.

Competing values framework (CVF) is a widely used model to measure the culture of an organisation. This tool includes a questionnaire consisting of six fundamental elements which build culture of an organisation. Culture of a BIM-enabled project can be measured to examine whether the project-based organisation is influenced by a particular organisation involved with the project or not.

Chapter 3

This chapter illustrates the theoretical framework of the methodology and methods which have been followed in this research. This includes understanding of research paradigms, criteria for residing into a particular paradigm, apprehendable knowledge, and methods followed to capture the knowledge in a particular area of interest. The discussion also explains how a researcher resides his or her position in one of the four research paradigms.

Grounded Theory (GT) is a methodological approach that is widely used in qualitative research. This approach comprises of a number of principles and sequential activities, i.e. interviewing, transcribing, coding, memo writing, theoretical sampling, and interpretation of data. Various notions are emerged during a GT study. Refining the notions and comparison among those lead to ground a theory. In a GT study, data collection and its analysis are performed simultaneously and continuously with the progressing collection of data at various steps.

Chapter 4

In this chapter, the practical application of methodologies and methods which have been used in this study. The applied principles and performed activities in this study are explained with examples. Also, the methodological triangulation that has been used to validate the findings in the GT study is described. Finally, data triangulation is also used to attest the results through a different data collected the investigated projects.

Chapter 5

Data analysis and deriving the results in this study is the major focus of this chapter. The data analysis includes bringing data at an analytic level and analyse it to identify the concepts or categories and indications of evolving a theory; then, data interpretations are performed to identify the links of each category to others. Data analysis also includes regression analysis and correlation test. At the end, CVF analysis has been performed to recheck the findings from GT study and regression analysis.

Chapter 6

This chapter describes the conclusion and understandings from the overall study. The theoretical underpinning of the elements of BIM and the culture of a project-based organisation is derived in this part. A number of substantia theories have been explained. This chapter also includes implications of this research in various aspects, limitations, and recommendations for future research based on the findings from this study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The construction industry plays an important role in the overall economy of most countries. However, it is declared in many reports that the underperformance of the industry has downsized the delivered value of the government's construction investment (Latham, 1994; Egan, 1998; 2002; CO, 2011). These rigorous reviews were performed to foster the efficiency of the construction project delivery process. The latest movement of enhancing efficiency by attaining a collaborative culture in the construction industry is through the implementation of BIM. However, there are number of potential barriers such as legal, contractual, technological, cultural, and human barriers. These barriers hinder effective integration, which is now major concern among the AEC industry professionals on adopting BIM. Extant literature suggests that the implementation of BIM influences the way of working and culture of project-based organisations. On the other hand, the existing culture has an influence on the success of the implementation of BIM. As such, the construction industry need to uncover the relationship between the culture of a project-based organisation and the implementation of BIM, including the individuals' behavioural approach and the interactions between the parties in a BIM project to overcome the issues raised in a BIM-enabled project.

2.2 Delivery Strategies and Management of Modern Construction Projects

It has been seen in the long history that construction projects are executed by various methods. During the earlier period, the main builder used to perform both design and construction. In course of time, construction projects involved a variety of demands and new criteria. As a result, management of a construction project became more complex. Beyond the formal contracting and organizational management review process, use of advanced technology has come into the major concern as well as the strategic application (SDLR, 2007). Thus, following the route of the project execution methods such as design-build and design-bid-build, partnering agreements were introduced to deal the large complex projects. Integrated Project Delivery (IPD) is the consequence of the growing body of knowledge to deal the complex construction projects effectively and efficiently. On the other hand, BIM is a technology-driven process which is emerged to embrace all participants throughout the whole lifecycle of the project (AIA, 2007a). The basic and common criterion of these two project management methods is the multi-party partnering alliance and collaboration. Following the attempts of attaining a truly collaborative delivery process, the recent movement is the implementation of BIM.

2.2.1 Integrated Project Delivery (IPD) and Integrated Project Insurance (IPI)

To deliver a construction project, a project management sets up the arrangements to manage or control the project by fulfilling the particular expectations (Glick and Guggemos, 2009). However, modern construction projects relate diverse expectations which are pushing the project management towards the critical edge. Increasing unpredicted demands and specialization of product with time necessitate more communication, and associates more risks during the management of various functional activities (AIA, 2007a). It is also understood that involvement of multiple stakeholders in a project requires extra efforts to manage them as part of a project (AIA, 2007b). IPD was initiated through attempts to address critical issues, barriers, and particular demands in the construction delivery process. It was inserted as a project delivery process in the procurement route of the construction industry in the United States. Due to the notable performance of enhancing communication and efficiency, IPD has become one of the most effective, successful, and popular construction project delivery approaches in today's modern construction industry. Integrated project delivery has a feature that tracks back the opposite side of the coin of IPD that is represented in the Integrated Project Insurance (IPI) in the United Kingdom. For instance, following the routes of the implementation of BIM, IPI project model comprises a unique process of collaboration and risk management. According to the principle, any trials have to be conducted under protected conditions. Thus, each of the initiatives whether IPD, BIM or IPI inherent the process of collaboration and improving efficiency in the construction project delivery process.

According to the American Institute of Architects (AIA), IPD is defined as "… *a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction*"(AIA, 2007a). The definition clearly describes the characteristics, purposes and benefits of this approach. Basically, the notion of IPD stands on collaboration. It embodies some basic principles and business model by which participants are harnessed to build an integrated team and achieve a common goal (AIA, 2007b).

According to AIA (2007a, 2007b), the key elements of IPD are: (1) collaborative design and construction process, and (2) sharing risks and rewards. To maximise the effectiveness of teamwork, IPD offers moderate incentives to all participants by sharing risks and rewards through the change in traditional contractual arrangements based on the best interest of the project (Wickersham, 2009). Extensive legal implications are embodied by these kinds of change for the key participants' business profitability and insurability.

Having capacity of binding more participants than the traditional contract provisions, IPD principles can be applied to different contractual arrangements (AIA, 2007b). It is asserted by the basic principles of IPD that the use of highest available technology moves IPD towards a more advanced level such as Building Information Modelling (BIM) (AIA, 2007a). In other words, gaining efficiency through IPD necessitates implementation of BIM to extract the best value for the project. It also ensures the early contribution of knowledge and embrace the contract parties in a technology-driven alliance.

2.2.2 Building Information Modelling (BIM)

Numerous definitions of BIM are given by different organisations and authors, such as "BIM is a technology that brings with a new way of working" (BSI, 2010), "BIM is a process that involves creating and using an intelligent 3D model to inform and communicate project decisions" (Autodesk, 2010), and "BIM is a way of working by which everyone can understand a building through the use of a digital model" (NBS, 2011). These definitions suggest that the meaning of BIM varies from tools, technology and up to a process. BIM has several features which varies from person to organisations. In a word, BIM is a high-tech driven process which unifies people, information, technology, and project delivery process into a single integrated process with a common understanding through the digital feature of a building.

Implementation of BIM is the latest transition route of enhancing efficiency through collaboration in the construction project delivery process. As an evolving paradigm, understanding of BIM is widening with time. It ranges from tool, technology, and up to a project delivery process today (AIA, 2007b; Glick and Guggemos, 2009; Ilozor and Kelly, 2012). It is a process where the 3D model of a building is developed by object-based components. The building objects carrying their geometrical attributes and relations to each other can be of different ranges such as undefined, generic or product-specific, solid shapes or void-space oriented (Mosey, 2005). These objects are linked to the central shared database containing the project information. In other words, it is a virtual replica of the building or infrastructure. The model can be used to produce design and construction documents, specifications and schedules. It allows representation of digital information of a building for different phases of the lifecycle (Gu and London, 2010). Though the basic model in 3D, it can be presented in further dimensions such as 4D (integrating time-lining), 5D (including cost schedule)– even up to ‘nD’ as per necessity of purpose (BSI, 2010). Basically, it is a collective process and all the involved parties work in a shared platform. BIM has two major attributes by which the value can be added throughout the process (NBS, 2011)

a) Data-rich technology,
b) Integrated design and construction.

Figure 2.1 shows the major participants connected to a BIM project (Source, Building SMART) (BSI, 2010). In a BIM-enabled construction project, the information contained in a model can be shared by different parties. BIM is the central source of information for all participants in a project. However, the information model is a contribution-based repository which is to be developed by the mutual efforts of the contracting parties (Underwood and Isigdag, 2009; Eastman *et al.*, 2011).

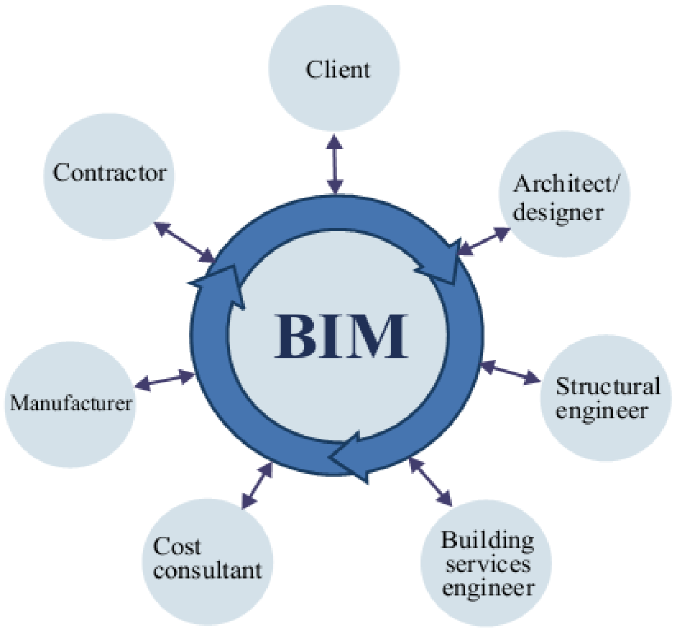

Figure 2-1: Participants in a BIM project

a) BIM as a data-rich technology

It has been noted that BIM is not CAD (Bew and Underwood, 2009). Hardin (2009) adds that it is a process to create a model with object-oriented CAD. The information model of the building contains graphical and non-graphical (digital) data. It is developed by a collective process of gathering data from relevant contributors. The major difference of 3D model and BIM is—3D model is non-digital model whereas BIM is digital model of the building. In BIM, the building elements are composed as 3D objects which are connected to the database containing necessary information of the project (AIA, 2007b). The data is kept in a single repository and shared by other disciplines as per individuals' purpose.

Basically, the information model is structured by abstract objects such as spaces, wall, doors, windows, HVAC and electrical components. Each object contains detailed specification of building elements such as room number, room name, area, occupancy, reference number for the dimensional calculations by other parties. The level of integration takes place according to the progress of development of the model and collaboration. BIM has following three levels based on information management, data sharing and collaboration (see Figure 2-2) (BSI, 2010; NBS, 2011):

Level 1: Information is gathered and blended in a structured form. Common standards and virtual building elements are been used at this level (BSI, 2010). Individual models are developed by architects and consultants, but the models are not shared.

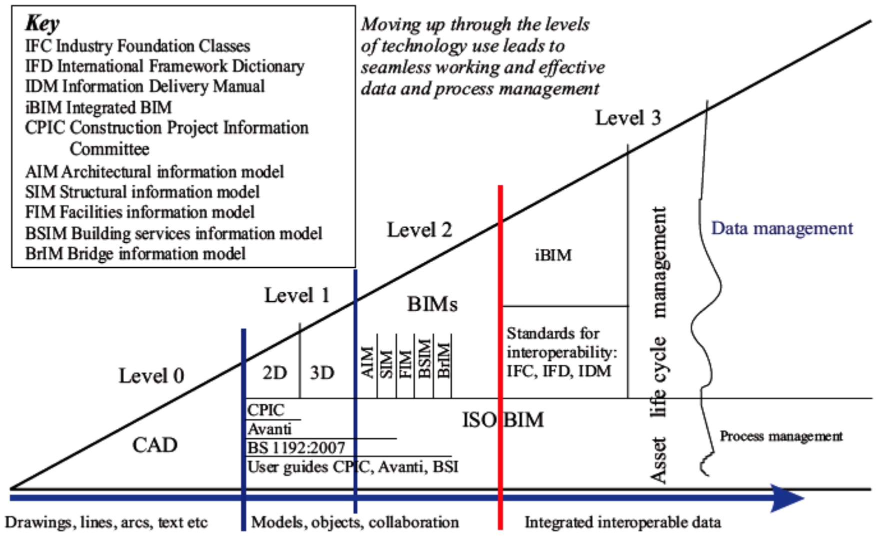

Figure 2-2: Levels BIM (BSI, 2010)

Level 2: Models are kept in a model library and brought together to share for specific purpose; for example, clash detection of building elements (NBS, 2014a). Relevant participants make mutual decisions for the actions to be taken. Thus, a number of integrations take place at this stage. In fact, the extra value to be added in a project through the implementation of BIM is started from this level.

Level 3: At this level, a common data repository, i.e. the combined model, is developed gradually (NBS, 2014a). For example, once the structural engineers drop the data into the model repository, the plumber uses the same information to accomplish the plumbing design. The model drives the establishment of a common language environment. This is the desired ultimate state of BIM. The most effective collaboration takes place in this process. Decisions are made together with effective collaboration. Being a data-rich technology, BIM enables development of a model of a building digitally considering the whole life cycle of the project. The digital model allows meeting versatile purposes such as 3D visualisation, building code reviews, forensic analysis for faults or failure, cost estimating, construction scheduling, and conflict or interference detection (Azhar *et al.*, 2011). Enhancing efficiency by earlier elimination of waste is a vital feature of this attribute (NBS, 2011).

b) BIM as integrated design and construction

The integrated design and construction attribute facilitate a shared platform to bring all the participants such as client, contractors, architects, designers, structural engineers, building services engineers and consultants together (NBS, 2011; Ilozor and Kelly, 2012). It facilitates in various aspects, such as involving different parties earlier, providing relevant contribution, enabling interactions, making decisions together, and ultimately work as a single team within shared vision. The whole construction process can be understood by the virtual representation of the model and development process (Glick and Guggemos, 2009).

BIM is a process where a digital model of a building is produced by synergistic effort of all participants (Philp, 2012). The model is developed gradually by the respective contribution of the participants. The whole life cycle of the project is demonstrated by the virtual model of the building through graphical and non-graphical features. It is mentioned that in a BIM-enabled project, the design phase overlaps the construction phase (Hardin, 2009). Hence, collaboration and seamless information flow are functionalised throughout the project delivery process. The waste of time is minimised and efficiency of the process is enhanced in this way.

In practice, a BIM project team is assembled by diverse skills from different organisations where all the parties are embraced by technical interdependency. Individual models are developed by different functional parties in the team (Hossain et al., 2013). For a specific purpose such as clash detection or risk analysis, the individual models are brought together for performing interactions between the individual models (NBS, 2011). By observing the construction process from the virtual models, any future hazards or risk can be detected earlier. An interactive and combined decision making process takes place to undertake a necessary measure; this fosters team cohesion (Philp, 2012). Parties can perform constructability rehearsal together to see the potential challenges. Thus, implementing BIM guides the parties to attain a collaborative process and culture by replacing blame culture in the construction industry.

2.2.3 The Relationship between IPD and BIM

Among the collaborative working arrangements, IPD is one of the most influential and effective approaches which accommodate dominant intellectual collaboration in a specific project (AIA, 2007a). However, IPD does not embrace the whole life cycle of the project and information flow remains fragmented (Glick and Guggemos, 2009). According to AIA (2007b) and Ashcraft (2008), IPD can be implemented without BIM but implementation of BIM requires an IPD team. Nevertheless, AIA (2007a) also recommend that to achieve effective collaboration through IPD, BIM is essential. Literature review suggests that BIM encompasses IPD integrally; the maximum benefit can be achieved when both are functionalised concurrently (Ashcraft, 2008; Wickersham, 2009; Ilozor and Kelly, 2012). BIM-enabled IPD offers effective process to embrace all the participants in the whole lifecycle of the project. It also enables integration of people and process, and improvement of information flow. Moreover, it allows the essential changes of delivery process by applying leading-edge technology in all spectrums of building projects such as design, construction and facilities management (Rosenberg, 2007; Arayici *et al.*, 2011; Malleson, 2012). Thus, the relationship between BIM and IPD is still an arguable issue (Hossain *et al.*, 2013).

Though BIM inherently contains some of the principles of IPD approach, it is not fully complementary with the basic IPD principles. Firstly, the responsibility, reward, and benefits of the individual parties are clearly defined in IPD alliance, however, in BIM, it is not defined yet (Rosenberg, 2007; Sebastian, 2010; Andre, 2011). Secondly, leadership is delegated to the most capable member with respect to the specific work and services (AIA, 2007b), whereas BIM needs additional management efforts to handle huge information. For example, BIM is based on the early contribution-based central database. A number of activities need to be performed to flourish communication and collaboration to structure the pool of information, which demands additional management body such as BIM Manager or BIM coordinator (Andre, 2011; Udom, 2012). Thirdly, IPD is a collective approach but not alike an overlapping of project phases of the whole lifecycle embraced by BIM. Therefore, BIM requires more attention such as contractual flexibility, beyond the distribution of risk and rewards by contract. Finally, unless the responsibilities, risks and rewards are clearly defined in BIM settings, fostering open communication and collaboration is ‘long way to go’. It is difficult to identify the contributor of the associated risk in process with overlapped activities and blended data (Rosenberg, 2007; Andre, 2011; Udom, 2012). Moreover, IPD is a process that primarily used as a procurement of construction industry in the United States whereas BIM is being used in the AEC industry for a long period (Bew and Underwood, 2009). In many countries, BIM is introducing as a mandate in the public construction projects. Thus, there are issues, such as communication, leadership, management of huge information, distribution of responsibilities, risks, and rewards, which indicate the cultural issues of BIM projects, which still need to be explored. As such, operation of BIM needs an additional attention than currently matured IPD.

Both IPD and BIM are used to increase efficiency in construction project delivery process by promoting collaboration and cooperation (Glick and Guggemos, 2009). These two processes knock down the adversarial culture in two ways. One is it embraces the parties in a single contract to work for a common goal by the primary concept of integration, and the other one is the coordination and integration between the parties is underpinned by technology (Ilozor and Kelly, 2012). BIM potentiate the similar concepts of managing construction projects to allow collaboration between the stakeholders within the supply value chain. However, also it is argued that IPD should be the endpoint of achieving the goal of BIM (Succar, 2009). Wickersham (2009) mentions that both of these are linked to manage the people and process, where BIM scaffolds integration and culture. Therefore, implementation of BIM has a linkage with IPD that is critical to attain a collaborative culture.

2.3 Usage and Benefits of BIM

Despite the new cultural and management issues, implementation of BIM is becoming significant part of the construction project delivery process. The versatile use of BIM promises extensive benefits to the wide range of participants than any other project delivery methods in the construction industry. BIM offers improved delivery process by using leading-edge technology and long-term thought of integration practise. Followings are the usage and benefits of BIM (Hardin, 2009; Azhar *et al.*, 2011):

a) The basic context of BIM ensures providing early efforts by the participants to minimise disputes and avoid clashes between the building components.
b) As the information is available on time in a single data repository, it potentiates less communication efforts to share information, and allows reuse of building information.

c) Change in design in an object based model facilitates automatic change in the adjacent required object(s). Hence, better design can be obtained efficiently. BIM also enables to analyse building proposals, quick simulation and performance benchmark. A better solution with less effort is attained.

d) The facilities management body can use the model to retrieve the necessary information for analysing faults or failure. Prediction of environmental performance for various options facilitates better understanding of the whole lifecycle cost.

e) The model has sound flexibility in producing documentation outputs. Various in-house outputs (including shop drawings) are possible to generate quickly.

f) Manufacturing of structural systems can be performed efficiently by exploiting data from the digitalised model of the building.

g) Clients can get a clear idea about the delivery process and final product by visualising the model and sequence of the construction process. It creates a new dimension of customer services and provides higher customer satisfaction.

h) All the information such as building code, design information, construction and operational information can be retrieved and reused by the facilities management in future. The whole lifecycle data is blended in the model which can be exploited later on as per particular necessity.

i) One of the notable usages of BIM is to use the model during the operation of the building. Forensic analysis for any fault or failure of any system, or, renovation scopes can be identified from the model analysis.

j) The model can be shaped in further dimensions (from 3D up to nD) to perform cost estimating, or construction sequencing such as material procurement and fabrication schedule.

k) Interference and clash detection can be performed by cross-checking between structural and MEP or electrical components such as ducting, piping, and wiring.

It is often argued that to extract optimum benefits from BIM projects, it has to be implemented with its full capacity (Ahmad *et al.*, 2012). However, implementation of BIM necessitates radical changes in the way of working and culture of the project-based organisations (Succar, 2009; Eastman *et al.*, 2011), which involves a number of barriers.

2.4 Barriers of BIM

Beside the versatile usage and tangible benefits of BIM, a number of barriers increasingly arise during the adoption of BIM. Numerous authors often argue that while parties move with adoption of BIM, complexity of the process is intensified gradually (Rosenberg, 2007; Dossick and Neff, 2010; Sebastian, 2010; Andre, 2011). It has been further mentioned by the authors that with the progression of the process of modelling, distribution of responsibilities and risks becomes unclear and more critical issues are raised. The noticeable issues are: habitual resistance, legal issues, cultural conflict and interoperability between the models produced by various parties. Barriers of the implementation of BIM are described in the following sections.

2.4.1 Legal and Contractual Barriers

One of the major prevailing barriers of the implementation of BIM is legal and contractual barrier. Existing legal and contractual arrangement have the following pitfalls on implementation BIM within the industry:

a) Inappropriate distribution of risk and reward

Rosenberg (2007), Sebastian (2010), and Ashcraft (2008) argue that distribution of risks and rewards are still imbalanced in BIM. According to Andre (2011) and Udom (2012), the industry needs to address the potential risks and the appropriate criteria of sharing or distributing them among the participants. The authors further mention that BIM-enabled project requires early involvement and contribution of the diverse functional parties. Philp (2012) adds that the optimum benefits of BIM come from the best teamwork. The team players have to conceive the belief about the best interest of the project and show their finest performance. Moreover, they have to feel free of unexpected forfeiture. Therefore, it is essential to figure out criteria to share risk and rewards among the parties to enable successful implementation of BIM.

b) Software related error

Andre (2011) and Udom (2012) mention that software malfunctioning or error is a common problem in today's high-tech arena. At a certain stage, the multiplayer contribution-based model becomes a massive database of context specific information.

Parn *et al*. (2015) argue that to workout with the model at various stages, application of different software packages is required. The author further mentions that the modelling approach involves different elements such as conceptualisation, design, execution, monitoring, cash flow, and other related activities. The whole process is connected with the virtual model of the building which is produced by using various types of software packages. Ashcraft (2008) asserts that the software related error can easily cause unexpected economic loss, for which the users do not have any realistic measure for recovery. However, according to Rosenberg (2007), in practice, there is no negotiation protocol of distributing risk or provision for insurance between the software vendor and designers.

c) Lack of standard document and proven strategies

Udom (2012) argues that the present contract documents do not cover the potential issues arise in BIM. The author further asserts that the implementation of BIM involves collaboration of different parties such as consultants, fabrication modellers, specialist manufacturers, contractors, sub-contractors and facilities managers. These diverse functional parties collaborate from earlier to develop the model as well as to build the project physically. According to AIA (2007b) sharing reward and risk accommodate extreme effectiveness in collaboration. Nevertheless, the current law stipulates clear winners and losers in every contract including the economic loss assessment and recovery (Andre, 2011). Udom (2012) further suggests that prior to moving forward towards a collaborative approach of BIM, current contract documents should be amended including provision for room to make changes in future accordingly.

BIM has changed the view of the application of technology in design, construction, and management of building projects. However, it is often argued that no suitable proven protocol is available yet (Rosenberg, 2007; Gu and London, 2010). As a result, numerous issues arise in different areas such as validation authority of the model, data administration body, design review in a blended sate of data, recommendation of appropriate framework of implementing BIM, licensing of signing authorities, and guidance for dispute resolution (Bernstein and Pittman, 2004; Sebastian, 2010; Andre, 2011). For an instance, a model containing building information or drawing is a collective product which is developed by a number of parties. Ashcraft (2008) argues that engineers or architects will be naturally reluctant to sign a document produced by the others as most of the state law instructs to sign their own documents.

d) Inappropriate distribution of responsibility of model development, reviews, and updates

Ashcraft (2008) argues that implementation of BIM is a radical change in the traditional project delivery approach. The author further highlights that it offers a progressive process of integrating design and construction, which demands a clear instruction of governance. Andre (2011) agrees with the author and adds that with the progress of the development of the model, the model requires regular review and update. It is also mentioned that updating each component automatically updates the relevant elements. Many authors add that despite being a contribution-based process, initiation and fabrication responsibility of the model is not clearly defined yet (Gu and London, 2010; Sebastian, 2010; Andre, 2011). According to these authors, in addition to the inappropriate liabilities distribution, no provision for fee is kept for model development and administration.

Similarly, there are some other issues which are not indicated in the legal implications of BIM. These are hosting liability of data, cost distribution for purchasing software and providing training, liability for design errors, responsibility of total quality of design, major to say (Ashcraft, 2008; Sebastian, 2010). Rosenberg (2007) argues that responsibilities of a participant change during the development of a model. Many authors assert that one of the critical issues of the implementation of BIM is the clarity of changing responsibilities of the participants (Gu and London, 2010; Sebastian, 2010). For example, BIM is now on a transition route to entrust the leading responsibility of design and construction or the whole process.

In fact, BIM eliminates the long-term process fragmentation by overlapping the phases of the whole life cycle of the project and enabling seamless information flow. However, the overlapping attribute affects the interface between the responsibilities of designers and implementation engineers (Ashcraft, 2008). It is essential to address this kind of issue between the parties which may evolve in a BIM-enabled project.

e) ***Undefined copyright, ownership, data access, and model security***
Versatile usage of building information model demands further regulating directions. According to Andre (2011), if the model is to be included as the part of contract documents, the contractor will be liable to do all the works in compliance with it which will make the model more complex within the process. In that case, it is necessary for the other parties to address the required parts or elements of the model to be accomplished by the contractor within the specified time. In contrary of this opinion, Sebastian (2010) argues that in the current practice of BIM, the models do not contain sufficient information to provide necessary guidance of the project execution.

BIM is a shared platform where all the relevant parties involve earlier and pay efforts to drive the progress of the integrated design and construction process (Philp, 2012). People from different functional organisations produce information in a common standard and share that information through a common data repository. A common level of understanding is also enabled in this process. In the traditional process, respective parties own their documents. Ashcraft (2008) and Sebastian (2010) mention that as the model is a collected product of different parties, it raises the question of the sole ownership of the intellectual property in a blended state. If the joint ownership is to be recommended, it is required to clarify all the responsibilities and provision for model security, data access, update, and confidentiality of the intellectual property of each party in the model. These issues require intensive effort of the participants. According to Udom (2012), the contract document should be in such a manner that will bind the parties to collaborate throughout the process.

When the various parties start to work in a BIM project, a number of contractual issues arises, as mentioned above. In practice, the existing contractual arrangement does not provide specific guidelines for contractual implications of BIM (McAdam, 2010; Andre, 2011). A number of authors mention that participants need to collaborate without being worried about adverse legal and contractual consequences (Rosenberg, 2007; Udom, 2012). Alongside the available contractual arrangements, the project participants need to synthesise their own requirements and suitable options for the specific project. A context-specific approach with suitable options allow the participants to achieve mutual benefits and long-term relationship by sharing detailed knowledge in specific situations (C2P2AI, 2008). Therefore, it is essential to explore the viable options and actions which need to be undertaken in a BIM project to minimise the legal and contractual barriers (Ashcraft, 2008). Investigation in this area will create a new context specific stock of knowledge which might be useful for the successful implementation of BIM.

2.4.2 Technical Barriers

BIM is a process underpinned by leading-edge technology. In such a technology-driven process, participants in a BIM project use different kind of software and technical infrastructure depending on their requirements and abilities. According to Andre (2011), as BIM is a high-tech and collective approach to modelling, limited technical configuration and diversity of software may not allow desired interactions between the models prepared by individual parties. The major technical barriers which appeared to be frontline issues in a BIM project are as follows:

a) Interoperability

Ashcraft (2008) mentions that organisations are committed to their own operation management, technical infrastructure, available resources, nature of business and self-capability. In current practice, models are developed by various companies by using different kinds of software. Sometimes, types of software used in different companies also vary accordingly with the size of the companies. Individual models are brought together for purposes such as clash detection or interface between the structural members and MEP components. Andre (2011) and Udom (2012) agree with Ashcraft (2008) and further suggest that software packages used by the different disciplines are required to be interoperable with the other BIM offered software packages. A standard format of information is required. The documents to be produced by various disciplines will contain necessary information. The parties have to update the information synchronously with the other BIM models which are developed with different software packages by the different parties. Otherwise, it will not be possible to perform interactions between the models or develop a single model by the collective process of gathering information.

b) ***Availability of necessary software, infrastructure and operation efficiency***
BIM is a process of delivering projects by using leading-edge technology (AIA, 2007b). The high-tech technology requires higher configuration of computer. According to Udom (2012), upgrading computers for conducting the process of BIM will involve significant cost. Without this technical infrastructure development, the computer operation performance will lose efficiency, which may affect productivity in the design process.

Operation of BIM involves fulfilling the technical requirements and necessary interactions between the pieces of information, which is closely congruent with the interactions between the diverse functional parties in a BIM operated project. It is often argued that participants in a BIM project are highly interdependent (Clough *et al.*, 2008). Many authors argue that success of a team in such a highly interdependent project depends on the cooperation of other parties (Mullins, 2010; Andre, 2011). Therefore, it is essential to investigate the technology–driven interactions between the parties which substantially influence the success of the implementation of BIM.

2.4.3 Cultural Barriers

According to Bew and Underwood (2009) and Hardin (2009), BIM allows necessary changes in the project delivery process by removing long-term burden of blame-culture and process fragmentation. However, according to Azhar *et al.* (2011), the habit of self-working-process and additional investment pull in higher experienced people and SMEs towards the traditional process from the technology-based collaboration. Numerous authors highlight that the cultural barriers are the most critical obstructions, which the construction industry need to overcome to implement BIM successfully (Yan and Demian, 2008; Philp, 2012). The cultural barriers which are often visible in BIM projects are described below:

a) ***Industry related and academic: lack of skills, education and training***
According to Bernstein and Pittman (2004), application of new technology fosters gaining efficiency in the construction delivery process; whereas, persons who will use it need to learn and adopt to obtain its potential benefits. Many authors argue that

implementation of BIM requires fundamental change in the traditional design and procurement process to get benefits of modern technology (Arayici *et al.*, 2011; Eastman *et al.*, 2011). It is not the learning of new software; it requires changes in the way of design coordination, resetting the workflow, training and reassigning responsibilities (SDLR, 2007). Such kind of adventure tracks back change management and shifting the culture where building mutual trust and cultural empathy is important (Cameron and Quinn, 2009). Human resistance is ubiquitous in this situation.

Recently, for example, in the UK, the specification for production and management of data in certain formats for a BIM-enabled CDE has been suggested by the construction regulating authority (BSI, 2013; 2014). However, several reports show that organisations face the challenge of emerging phenomena created by a huge volume of data which is generated during the project delivery process (Lock, 2012; Russom, 2013). The reports further state that organisations face challenges to manage information, not just volume, but also complexity as the particular data has linkages to various complex database. This is done for design coordination and retrieving data during the operation phase of the building. Accordingly, this non-traditionally structured data, termed as "*big data"*, requires specialised infrastructure and relevant skills. A concern is raised in the reports that sources of data are expanding which challenges the analytical process to transformation and use through the available system. Such an unfamiliar complex situation stimulates stress, and calls for particular attention to overcome growing concerns in the rapidly developing technology.

Ashcraft (2008) argue that although modern tools help to increase productivity in construction, it demands initial investment to replace the existing technology. The initial efforts to organise training for the people, hiring new employee, and buying software are major. All this activities involve additional cost to the organisations, but no fee is allocated for the professionals. Many authors highlight that there is no immediate return visible in the current state of BIM adopted projects, and most of the SMEs are not capable to undertake required training (Bernstein and Pittman, 2004;

Gu and London, 2010; Sebastian, 2010). There are less opportunity and cross skilled professionals to provide particular types of trainings. Academic courses also do not cover required curriculum facilitate fresh graduates on participating BIM activities (Azhar *et al.*, 2011).

It is a long period for AEC industry of using 2D CAD paper-based drawings for construction projects(Eastman *et al.*, 2011). The margin between design and construction phases is crossed by handing over 2D drawings. According to Hardin (2009), BIM eliminates this fragmentation by overlapping the phases and, thus, squeezing the overall duration of the project. However, it is difficult to give up the long-term habit of using paper based drawing and adopt 3D model for construction coordination (Gu and London, 2010). Also, the hesitation of experienced professionals is one of the pragmatic barriers to BIM implementation. Nevertheless, it is essential to utilise the skills of experienced professionals in the modelling process to avoid robotic judgement.

b) Lack of motivation

An well distribution of risks and rewards among the participants fosters effective collaboration (AIA, 2007b). When the goal of the implementation of BIM is attain a certain level of collaboration facilitated by defined technological application, motivation is an important issue. Nonetheless, in the process of BIM, there is a lack of motivation embraced by asymmetrical distribution of risks and rewards, and invisible financial return or benefit for the initiators such as designers (Gu and London, 2010; Sebastian, 2010).

Beside the barriers discussed above, there are also a number of factors which hinder teamwork in construction projects. These are attitude to work together in a shared platform including lack of trust, silo thinking, and recognition of rewards (Macmillan, 2011). According to Andre (2011), in a BIM project environment, where the multi skilled players work together in a formal partnering relationship, these issues tend to arise frequently and pragmatically. Ashcraft (2008) adds that along with the development of modern technology, the gap between legislative requirement and improved professional practice is broadening. For an evolving technology such as BIM, the contract documents may not be contemporary with the arising issues (Ashcraft, 2008). In absence of practical and proven protocol, inter-disciplinary clash is likely to happen, which severely affects integration of both people and process.

Furthermore, a construction project comprises teams from different organizational cultures along with the individuals having different social needs (Roma and Ogunlana, 2009). Also, the combined team includes experienced and young players, and both are essential for a project. In such a situation, absence of cultural empathy promotes a confrontational environment which hinders effective teamwork (Steele and Murray, 2001; Macmillan, 2011). In a new process with leading-edge technology, team players' feeling of being unvalued or dispensable is very likely to exist (Macmillan, 2011). Thus, social loafing can easily take place which causes a knock down effect on teamwork effectiveness (Macmillan, 2011). These critical attributes of teamwork often hinder collaboration and innovation within the process.

Based on the above discussion, it can be argued that the implementation of BIM involves particular skills and readiness to carry out the process, for which the industry is still not prepared. Also, the application of a highly technology-driven process necessitates investment for which the majority of the companies within the industry are not yet prepared. Therefore, the construction industry is facing numerous issues to implement BIM successfully.

2.4.4 BIM Implementation Plan and BIM Protocols

It is suggested that to realise benefit from the implementation of BIM, it is necessary to articulate a BIM execution plan (Autodesk, 2015). An execution plan includes necessary information and the plan is followed through certain checklists which are called BIM protocols. In a typical BIM execution plan, certain elements such as information on project context, objective and goals, collaborative working arrangements, project resources and IT requirements for a particular project are explicated (AEC-UK, 2012).

A BIM protocol is the bunch of documents used to review the execution plan at different milestones. This also includes definitions of entities and terms and conditions to carry out the BIM implementation plan (CIC, 2013). In a BIM protocol, obligations of various parties in terms of participating in the modelling process are also mentioned. A BIM implementation plan and BIM protocols are set up by the top management of the project-based organisations.

2.5 Teams and Teamwork

Definition of team is given by many authors based on the key features of a team. Katzenbach and Smith (1993) define a team as "a number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable". Larson and Lafasto (1989) also define a team as "a unit of two or more people who interact and coordinate their work to accomplish a specific goal". Both perspectives indicate that everyone is part of a team. For instance, each person is a member of a family team, working staff team, or, social event, or, entertainment team, or, any other team. People become a part of a team for different grounds or purposes. A team is developed with a distinct identity, mutual support, and coordination to achieve a common goal. The key feature of a team includes the following attributes (Harvey *et al.*, 1998):

- two or more people
- common purpose
- shared or common goal
- task interdependency
- desired and productive outcomes

The practice of teamwork has been initiated and nurtured within organisations to extract benefits on problem solving and decision making through a participatory process. Many authors mention that a teamwork requires strong commitment of the members to achieve the common goal. This helps the organisation to improve morale, enable creativity and innovation, reduce expenses, improve quality, increase productivity, and enhance organisational effectiveness (Parker, 2007; Gunduz, 2008; Sheng *et al.*, 2010). With time, teamwork has become an essential part of success in the workplace. Macmillan (2011) adds that teamwork is reinforced by harnessing collective skills of individuals to fulfil a specific purpose. The author further notices that teamwork offers better performance than individuals could gain separately. Especially, in a BIM-enabled construction project where collaboration is central attention, collective approach of work is essential. This is an obvious challenge of sifting culture (Rosenberg, 2007; Philp, 2012).

2.5.1 Development of Teamwork

Many authors point out that over 30 years ago, organisations started to shift from a bureaucratic structure towards a team approach. For instance, Toyota, Volvo, Australian Tax office introduced teams in their different operational areas while they were in a highly formalised and hierarchically structured (Harvey *et al.*, 1998). Parker (2007) mentions that within a few years, a team approach spread rapidly among the organisations, especially, in the larger firms.

Macmillan (2011) mentions that teamwork was grown to meet the difficulties where multifunctional skills are essential to perform the task. A number of authors add that teamwork was adopted by the organisational leaders due to its tangible benefits such as immediate feedback, better commitment, common norm, more loyalty, and strong ties among the members of the workgroups (Parker, 2007; Sheng *et al.*, 2010). In the modern era, teamwork is considered as a critical aspect business strategy where team players are valued partners. Many authors highlight that the most common use of teams is in the established groups who are in the lower position in the organisational hierarchies (Woodman and Sherwood, 1980). According to the authors, teamwork was introduced to meet the specific tasks with following attributes:

– presence of complexity,
– desired better efficiency than individuals, and
– presence of interdependency within the task environment.

Based on the discussion, it can be concluded that teamwork approach was evolved by attempting to improve organisational efficiency to accomplish large and complex tasks. Nevertheless, study on teamwork asserts that simply forming a team will not provide a desired output unless the team comprises some essential traits.

2.5.2 Fundamental Attributes Effective Teamwork

To ensure effective teamwork, a team must develop the essential attributes. Otherwise, employee resistance or conflict may occur which will reduce the group performance (Harvey *et al.*, 1998). A number of authors point out the following factors which must be considered during building up the teams:

Commitment to team success: Team members have to be firmly committed to achieve the team product as desired (Mickan and Rodger, 2000; Tarricone and Luca, 2002). For instance, in an IPD or BIM-enabled project, specific commitment on deliverables is one of the key elements to success.

Clear and shared goals: A clear goal must be provided earlier to ensure the team direction. A clearly defined goal guarantees the employees to work with freedom and confidence about their achievements (Harvey *et al.*, 1998). It helps the members to connect with common understanding and shared goals (Mickan and Rodger, 2000). This allows the members to engage more effectively and motivate them towards the aim of the project (Tarricone and Luca, 2002).

Interdependence, collaboration, participation: An environment should be created in such a manner that the members can collectively contribute more than as individuals towards the committed task (Tarricone and Luca, 2002). While team members are more positively interdependent, the environment enables the players to learn and contribute to achieve the goal. Sharing knowledge is a big advantage of this attribute (Mickan and Rodger, 2000). For example, in a BIM-enabled project, people share information in a way that each party may be interdependent to the information of a certain party (Ilozor and Kelly, 2012). If the architectural model is not produced, the other parties need to wait till the part of the model is prepared. In this case, an architectural model is the reference model for other parties. Hence, the overall collaboration necessitates the active participation of all parties.

Trust, mutual respect and helpfulness: Trust among the members is an essential element to team success (Mickan and Rodger, 2000; Macmillan, 2011). Players should have mutual respect and helpful attitudes to each other.

Interpersonal skills: The skills which make a person to integrate better with the other members. This means the ability to discuss issues with others, honesty, trustworthiness, supportiveness, commitment and mutual respect; i.e., the ability to work with others and maintain a caring environment (Harvey *et al.*, 1998; Tarricone and Luca, 2002; Sheng *et al.*, 2010).

Open Communication and positive feedback: To create an effective teamwork environment it is essential to carry out the practice of active listening to the raised issues and requirement of the team members to perform the task, and appreciating the team members' contribution (Mickan and Rodger, 2000; Tarricone and Luca, 2002). However, team members have to be positive on constructive criticism and realistic feedback (Macmillan, 2011).

Appropriate team composition: This is one of the most key factors that influence the team effectiveness. People with essential skills need to be gathered and proper direction should be provided so that the team players clearly understand their team role and individuals' role within the team (Harvey *et al.*, 1998; Mickan and Rodger, 2000; Tarricone and Luca, 2002; Macmillan, 2011).

Commitment to the team process, leadership, accountability, and responsibility: It is vital to motivate the team players to ensure their accountability for the contribution to the team and project (Tarricone and Luca, 2002). For instance, team members' feeling of having decision making authority allows them to feel more accountable and responsible (Harvey *et al.*, 1998). Nevertheless, teams need to evaluate themselves with respect to the customer satisfaction and the goals. Alongside these attributes, effective leadership, shared decision making and problem solving is also essential to create an effective team (Mickan and Rodger, 2000; Parker, 2007; Yun *et al.*, 2007).

Positive and productive group norms: Setting productive and positive group norms is an important factor to establish a comfort environment and team cohesion among the players (Harvey *et al.*, 1998; Sheng *et al.*, 2010). The behaviour of team players is influenced by the adopted group norms (Macmillan, 2011).

Training and Development: To work more effectively, members may need to undertake training as the people may need to learn few new things. As the work environment is new and the team effectiveness relies upon the integration of people and process, it is essential to train the people to make the level of understanding up to the team standard (Harvey *et al.*, 1998).

Access to resources and organisational support: To enable smooth operation, team members should have necessary access to resources in terms of finance, technology, infrastructure, and intellectual properties (Harvey *et al.*, 1998; Mickan and Rodger, 2000). However, resources should be allocated as per necessity. Moreover, support from middle and top management is required (Parker, 2007).

Rewards to the team success: A provision for team based-reward fosters team success and reduces the attraction towards individual goal performance goal. The team-based reward would include the contribution of individuals to the team success (Harvey *et al.*, 1998; Parker, 2007).

Indeed, the presence of fundamental characteristics of a team promotes the probability of team success. Nonetheless, flexibility, cultural empathy, and supportive attitude must be existed among the players to functionalise effective teamwork. However, since the implementation of BIM necessitates parties undergoing a technology-driven process, allowance of flexibility can appear as a new issue.

2.5.3 Barriers of Effective Teamwork

Macmillan (2011) asserts that a team is composed with the people from different backgrounds and social needs. Especially, the concept of modern construction project team goes further than the traditional practice. For instance, a team involved in a modern construction project is a virtual team, and the parties may differ from various aspects such as locations, languages, disciplines, and cultures. Though a multifunctional team offers more innovative and better solution than mono-functional or individual actions, team members often face the following barriers:

Communication difficulties

One of the key barriers of effective teamwork is difficulties in communication. Communication among the team members becomes difficult while (Parker, 2007)-

–the team members are located in different locations,

–there is a difference in language among the team members,

–a cultural difference is present,

–limited electronic communication technology,

–inadequate interpersonal relationship is developed,

–no informal events such as events in hallway or cafeteria, and the events in sports centre or outdoor recreational places are undertaken.

Cultural barriers

According to Macmillan (2011), multicultural team is very common in the construction industry. This cultural diversity ranges from discipline, region, nationality, religion, or in any other perspectives. People gathered from different cultural backgrounds have different kinds of language, understanding, decision making styles, leadership styles, management styles, and conflict resolution procedures (Parker, 2007). These cultural differences often push team members towards conflict, from which they may have bad feeling which may downsize the cultural empathy between each other. Such kinds of situations can directly knock down the team effectiveness.

Inappropriate planning and team direction

Numerous authors argue that a team should know what they are exactly going to do, how to do, and who is going to do which task; and the whole team must know the team intention and the way to achieve the common goal (Harvey *et al.*, 1998; Parker, 2007; Pell, 2010). According to Macmillan (2011), if team members are not clear about their goal and team expectation from the individuals, they will not be willing to pay maximum effort. The author further suggests that the common goal must be compatible with the individual organisational goal. A goal conflict will certainly affect the collective productivity. As such, planning and team direction should be appropriate matching with the team players individual skills and organisational goals.

Lack of loyalty, trust and commitment

When there is a deficiency in loyalty, trust and commitment exist among the team members, it prevents the individuals to provide maximum contribution and be helpful to each other (Pell, 2010). Collaboration and coordination are directly affected by this lacking. Many authors suggest that responsibilities should be properly distributed among members of the team to ensure their accountability and commitment (Mickan and Rodger, 2000; Macmillan, 2011).

Poor leadership

Appropriate leadership is a critical requirement of team success. A poor and inappropriate leadership may case a huge mess within the teamwork (Mickan and Rodger, 2000; Pell, 2010). For instance, failure to keep consistency in team cohesion, resolving the conflicts raise, managing and providing decisions on constructive debate can affect teamwork success. Without proper leadership a team may suffer from confusion and dilemma. However, there are various styles of leaderships which are practised in the construction projects. For this research, the key focus in terms of leadership is to investigate the understanding and involvement of the project leader on the process of BIM in the BIM-enabled projects.

Ineffective training

Ineffective training costs resources and does not add value on team productivity (Pell, 2010). Moreover skilled personnel spend their time on training programme. Each participant need to perform at higher level to move forward. If the team members are trained, the training should be effective.

Inappropriate recognition and reward provision

It is a usual expectation of the employee that if they work hard, they will be appreciated, recognised, and rewarded (Pell, 2010). Failure to establish a reward provision, team members will not be willing to pay their maximum effort.

Silo thinking

A silo thinking is an organisational condition when the organisation does not share information (Beal, 2016). In an organisation, this condition can include sharing the systems with that the organisations are working. Each organisation has its own strategy on leadership, market completion, organisational goal, and technique to measure effectiveness. If the team goal is not synchronised with the organisational goal, the team players may not contribute spontaneously (Pell, 2010). For instance, if any organisation in a BIM-enabled project do not want to share information through the common sever, that will create obstacle to other organisations which need that information to proceed.

Social loafing

In an organisation or team, social loafing is the tendency for individuals to pay less effort than when they are working individually (Karau and Williams, 1993). Social loafing is one of the largest hazards to team success. If the team members are not valued properly, the employee may have feel ‘dispensable’, social loafing takes place in this situation and it reduces team productivity (Macmillan, 2011).

The above discussion suggests that it is challenging to establish an effective and functional team. Organisational leaders have to undertake the appropriate approach to deal with each particular team. To foster team effectiveness, in terms of teamwork, theories and models are developed in the modern business world.

2.6 Teamwork in Construction Projects

Construction projects are carried out by multidisciplinary participants. Especially in a large project, parties derive from diverse disciplines and different regions. As such, diversity of culture, language, and background is ubiquitous in modern construction projects. It is often argued that rather than a typical teamwork within an organisation, an inter-organisational teamwork is developed in construction projects (Fong and Lung, 2007).

In the modern era, joint venture and multi-party partnering in the modern construction industry more progressively introduced teamwork (Toor and Ogunlana, 2007). To avoid adversarial relationship and create cooperative environment parties agree to undergo an agreement to work together as a virtual and temporary team.

2.6.1 BIM Perspective of Teamwork

The construction industry reports called for collaboration from a long period. For example, in the UK, Latham (1994) provided a set of recommendations which was focused on teamwork. The series of reports such as Egan (1998, 2002) also indicates collaborative work practice to depart the construction industry from underperformance. The recent construction strategy (2011) undertaken by the UK government enforced a collaborative process of delivering construction project. The strategy asserts that the whole construction lifecycle would be managed in a way that all parties involved in a project must be working with high level of independency and collaboration. Additionally, it is also suggested that the whole process and parties are to be underpinned by certain technology, i.e. BIM (CO, 2011). The implementation of BIM ties all parties and facilitates the access to the required information in a construction supply chain. BIM is already mandatory in various countries such as Finland, Norway, and Denmark.

The assertion of BIM in the AEC industry indicates the necessity of highly integrated team to carry out the process of information modelling. However, attributes of a team in a BIM project differs from traditional practice. For instance, a BIM project team is a virtual team where participants are highly interdependent due to the nature of managing information and usual sequence of construction phases. Compared to an engine composed of a number of functional parts, a BIM project team is the engine where function of BIM is to supply power. However, as all the parts must be working perfectly to operate the engine, all the participants must be paying a balanced effort. Many authors suggest that in a BIM project, this kind of function requires synchronisation of all different aspects such as realistic planning, appropriate leadership, a well-defined team goal, trust, mutual respect, commitment, collaboration, and provision for recognition and rewards for team success or outstanding players (Harvey *et al.*, 1998; Mickan and Rodger, 2000; Parker, 2007; Pell, 2010).

Numerous authors mention that success of a BIM-enabled project relies upon the level of collaboration takes place among the participants of the whole process (AIA, 2007a; Andre, 2011; NBS, 2011). Therefore, simply assembling a team and assigning tasks will not bring the collective success in a BIM project. The authors further assert that the management of a construction project stands on a critical edge of effectiveness due to certain factors such as time frame, limited resource, new situation, and potential challenges in each unique project. It is always critical to take any action on it. An improper decision may affect the overall team performance.

With globalisation and revolution of communication technology, success factors of construction projects are becoming wide ranging (Toor and Ogunlana, 2007). Consequently, industry concern is increasing and studies on success factors of large construction projects are increasing. A BIM project is a new environment where latest technology will embrace the people and process. Also, the team differs from traditional team as the virtual team is engaged gradually according to the progress of model and project. Moreover, it is deemed that the frequent face-to-face interaction between the parties is not necessary. Such kind of situations in turn hinders integration among the parties in BIM environment.

2.7 Culture of the Construction Project-Based Organisations

Meaning of 'culture' varies according to the diversity disciplines and level of perception; sometimes these are controversial (Thompson *et al.*, 1990; Robbins, 2003; Buchanan and Huszynski, 2010). From the definitions given by different authors, it can be outlined that the meaning of 'culture' stands for the reason behind the behavioural response to the environment driven by the values shared by members of the local society (Hoebel, 1960; Hofstede, 1980). It is also argued that the meaning of culture resides on "shared values, understandings, assumptions and goals learned from earlier generations and apparently resultant of which guides the behaviour" (Losemore, 1999). Later on, the definition of culture was refined by illustrating the distinctive behavioural traits—which is a collection of values, beliefs, behaviours, customs, and attitudes of the peoples living in the societies (Fan, 2000). In another view culture is "The way we do things here" (Deal and Kennedy, 1982). Thus, understanding of culture has been spread across the different spectrums of behaviour in a certain environment. The definitions given by different authors assert that culture has an influence to the surrounding environment as people response by their nature; and the response is driven by culture (Hoebel, 1960; Hofstede, 1980). Since a construction project is a temporary venture where people gather from diverse functional organisations (Roma and Ogunlana, 2009), culture of a project-based organisation builds gradually from the initial stage of a project and responses of the peoples are guided by a number of factors such as shared values, understandings, and assumptions inherited within their parent organisations. In a BIM enabled-project, the project culture is the outcome of the understandings, assumptions, beliefs, and goals shared by the various parties. These elements of culture are developed and inherited by the technology and process of BIM.

According to Roma and Ogunlana (2009), culture in a traditional construction project-based organisation is comprised by different organisational cultures. Many authors argue that in this kind of project setting, cultural conflicts often create a confrontational environment and ultimately lead to an adversarial culture (Abeysekara and Lata, 2002; Cain, 2003; Dossick and Neff, 2010; Macmillan, 2011). Philp (2012) argues that this adversarial culture is reinforced by process fragmentation. The author further demonstrates that the implementation of BIM is intended to eliminate process fragmentation and functional adversaries by overlapping construction phases and enable effective collaboration throughout the construction project delivery process. Numerous authors often share a common conviction that such a revolutionary move involves fundamental change in working styles, which is a massive cultural shift from an adversarial culture to a collaborative culture (Succar, 2009; Eastman *et al.*, 2011; Arayici *et al.*, 2012). However, several authors argue that beside applying the latest technology, it requires combined effort of all the participants throughout the process (Gu *et al.*, 2008; Hardin, 2009; Gu and London, 2010). Rosenberg (2007) and Andre (2011) mention that development of the model depends on the contribution of the participants. Based on this discussion, all parties need to focus on the common goal by minimising the incongruence of culture within the project.

It is often argued that culture is dominated by 'stable factors' (Williums *et al.*, 1989), which contradict with the culture of project-based organisations where the organisations is not stable itself (Roma and Ogunlana, 2009). In the modern world, another view of culture is seen as 'software' within organisation itself is a hardware (Sun, 2008). This analogy fits with the true setting of an organisation which is driven by technology, for instance, a project setting which is underpinned by technology. ,It has been highlighted by many authors that a composite culture is sustained by following certain factors based on the cultural elements in a BIM-enabled project, as a project-based organisation (Hoebel, 1960; Losemore, 1999; Hofstede, 2001; Sun, 2008; Gu and London, 2010; Andre, 2011; Cameron and Quinn, 2011; Eastman *et al.*, 2011):

a) Leadership

The term 'leadership' is viewed diversely, ranges by behaviour, characteristics, and outcome results or end results (Kasapoğlu, 2011). To meet the appropriate leadership approach for diverse settings in modern era, different authors prescribe a range of leadership approaches such as 'situational leadership' (Hersey and Blanchard, 1993), 'adaptive leadership' (Newton, 2008), and 'creative leadership' (Rickards and Moger, 2000). Toor and Ofori (2008) suggest that in modern globalised construction industry, it is necessary to apply different kinds of skills, knowledge and styles of leadership; which indicates a new breed of leadership style i.e. 'authentic leadership'. Walker and Walker (2011) agree with Toor and Ofori (2008) and address the essential characteristics of ‘authentic leadership’ for different situations. In a study (Grendstad and Strand, 1999) it has been found that diligence to achieve a goal is the primary requirement of a leadership role, whereas the integration of behaviour appears as a secondary role requirement for all different types of organisations.

Many authors believe that despite leadership being a critical determinant of team effectiveness and significant importance thrived in construction management, there is a lack of completed study and discontent on achievement on leadership development in the AEC industry (Newton, 2008; Walker and Walker, 2011; Back and Macdonald, 2012). Continuous attempts and emerging arguments suggest that the appropriate approach of leadership for a specific situation is an arguable issue. Especially, in BIM projects, participants need a clear aim and direction to carry on the process and a project leader is a vital role (Andre, 2011). According to the particular context of a BIM project, a context-fitting leadership style is essential to meet the challenges of the implementation of BIM adoption (Hossain *et al.*, 2013). The authors further argue that a context-fitting leadership in a new technology-driven process demands several criteria of a leader such as particular actions of a leader in a BIM project, decision making process of a leader, the involvement of a leader with the activities of BIM.

b) Behaviour of the people within a project

Numerous authors agree that each construction project is composed of people from different socio-economic background and culture, where people have different understandings of self, of other, or the interdependent parties (Markus and Kitayama, 1991; Toor and Ogunlana, 2007; Roma and Ogunlana, 2009). Also, individuals’ behaviour is driven by certain factors in certain situations. Implementation of BIM ties the parties in a shared platform and reciprocal interdependency by high-tech-driven process (Clough *et al.*, 2008; Redmond *et al.*, 2012). It is often argued that the behaviour of contract parties in a construction project is seen as competing nature as all the parties effort to secure their own economic interest (Latham, 1994; Fleming and Koppelman, 1996). According to Dossick and Neff (2010), this kind of attitude affects the collaboration between the parties, which in turn hinders improving efficiency within the project delivery process.

According to Hossain *et al.* (2013), the high-tech-driven process of BIM does not necessarily motivate the people to extend hand of cooperation and a conflict of interests exists among the diverse fictional partiers. The authors further mention that behaviour of the participants in a BIM project can be guided through the technology-driven process of BIM and enable effective collaboration once they are self-motivated. Rosenberg (2007), Eastman *et al.* (2011), and Udom (2012) assert that the critical part of behaviour of the participants in a technology-driven environment relies on the certain factors such as coordination and integration in a shared data environment, decision making process, and interactions between the parties.

c) Goals in a BIM project involves cultural shift

Number of authors share a common conviction that a clear and achievable goal is a critical determinant of the success of a construction project (Morris and Huge, 1986; Munns and Bjeirmi, 1996; Macmillan, 2011). According to Arayici *et al.* (2012) and Hossain and Munns (2015), goals in a BIM-enabled construction project involves extracting optimum project value via effective communication and collaboration among the parties in a high-tech-driven process. The authors further claim that achieving such a target in the project delivery process involves cultural shift within the industry.

d) Understanding on the process

Implementation of BIM involves production of a high volume of information in desired format (BSI, 2013; Russom, 2013; BSI, 2014). Indeed, the whole project delivery process undergoes through a dynamic process of information management where participants use and contribute information accordingly. Number of authors mention that understanding on deliverables in a BIM project is an important issue and to ensure the deliverables requires particular skills (Hardin, 2009; Hossain and Munns, 2015; Parn *et al.*, 2015a). As such, to achieve the goals through the implementation of BIM demands a common understanding on the whole process including the fundamental requirements for deliverables i.e. supporting infrastructures and necessary skills both of which requires significant amount of investment.

e) Desired capacity and skills of the participants to achieve goals

Many authors mention that software tools used in a BIM project are influenced by several factors such as size of the organisations involved, availability of related software in the market, existing practice within the multi-functional organisations, and capacity of the organisations to invest on IT sector (Gu and London, 2010; Andre, 2011; Arayici *et al.*, 2012; Khosrowshahi and Arayici, 2012). Various organisations use numerous software packages which suit their organisations and existing skills practice within the individual organisations involved in the project. It has been widely believed that production of information require certain formats and volume which demand particular skills (Lock, 2012; BSI, 2013; Russom, 2013; BSI, 2014). As such, achieving goals such as ensuing deliverables and coordinating in a CDE necessitates particular capacity and skills of the people involved in a BIM-enabled project.

f) Assumptions

According to NBS (2011) and Hossain and Munns (2015), the value proposition of BIM with its full capacity within a particular project setting is an arguable issue. Participants in a particular BIM project undergo adoption of a new process by considering certain aspects such as inherent value of project to be extracted through BIM, necessary actions to extract values, and undertaking of new activities in a transition period of the adoption of BIM (Philp, 2012). For example, clash detection by digital overlays is a new activity in BIM projects than in a traditional project. When clash detection is performed, the clash between the functional elements of the building is thought to be real. Parties further believe that if the clashes can be removed from the digital 3D model, actual clash will be removed from the actual building. This common belief discourages the team members to dispute on design inconsistencies of individual parties. There is less tendency of argument exists between the parties in the BIM-enabled project. The blame culture is eliminated in this way.

g) Contractual arrangements and the culture of construction projects

There are a number of forms of contract that is suggested and applied to the BIM enabled projects. These various contracts provide necessary guidance and opportunities to facilitate desired collaboration in the construction projects. In terms of managing the team, roles and responsibilities are defined in these contract models. For example, a

> Joint Contracts Tribunal (JCT) contract suggests the size of the project that will be cost effective and flexibility (Dunn, 2016). A complex and large BIM-enabled project has numerous functional components and large team which can be managed by this type of contract. Another form of contract is also frequently used in the construction industry is New Engineering Contract (NEC). This contract form has particular attributes which drive construction project-based organisations to stimulate good management, use clear and simple language and which is easily understood, have wide application and are flexible (Cousins, 2007). Such attributes, especially the flexibility and purposeful guidance can provide useful guidelines in critical moments of project management while adopting and new technology and process. Thus, the way of work or behaviour of the people within a project can be articulated to a certain extent through these contract models. Thus, form of contracts may have influence on the culture in a BIM-enabled construction project.

It is often argued that the success of an interdependent teamwork relies on the cooperation of other parties and appropriate direction of the organisations (Clough et al., 2008; Mullins, 2010; Andre, 2011). However, practitioners in the construction industry are habituated to self-working process. According to Yan and Demian (2008) and Philp (2012), the adoption of BIM involves massive habitual and cultural change. The elements of culture associated with BIM drive the way of work within the project.

2.8 Untold Symbolic Interactions in BIM-Enabled Projects

Numerous authors believe that during a changing environment, actors decide their destiny with their actions (Blumer, 1980; Solomon, 1983; Nooy, 2009; Pascale, 2011). The construction industry is in a period of the cultural shift, i.e. the changing path of the way of working in the construction projects (Eastman *et al*. 2011). Consequently, the people in the industry are now in a position to find the appropriate means to cope with the rapid development of technology. Also, practitioners in the industry hold diverse views, beliefs, and aims towards the new settings (Rosenberg, 2007; Gu and London, 2010). As the activities in a BIM project are conducted through a shared participation, during this transition period individuals' actions influence the overall on-adoption process. Such an inherent process of multi-disciplinary participation in a new process and the resulting influence are still unknown to the industry. All these issues indicate the presence of symbolic interactions among the people in the construction industry. For instance, controlling data is a new way of managing data in BIM-enabled construction projects. Participants use a number of words to express their view on the topic. For example, some used words in the projects are ‘information management’, ‘data management’, or ‘data control’ to indicate managing information.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Overview

This chapter describes about the research design and methodology followed to carry out the research which includes understanding the fundamentals of research platforms, assumptions, and subsequent guidance for collecting data and its analysis. In this chapter, firstly, the philosophical stance of the work is discussed in terms of research paradigms; then selection of research methodology and used methods are explained.

3.2 The Research Context and Process

The aim of this research is to explore the inherent phenomena that is taking place within the construction projects while the participants are adopting a new process of delivering the construction projects. According to Philp (2012), Andre (2011), and Eastman (2011) the adopting project delivery process is underpinned by an information modelling process (BIM). This involves learning and applying new tools to produce and manage information, coordinate with the various functional parties within the supply chain, and embed the modelling process with all the phases of the project throughout the whole lifecycle of the project. The authors further claim that implementation of BIM within the project delivery process involves shifting of culture within the industry, i.e. the adoption of information modelling process changes the behaviour and way of work within the supply chain of construction projects. Crotty (1998) and Patton (1990) mention that investigation of such kind of phenomena that involves behavioural and cultural issues are categorised as social research.

Many authors often share a common conviction that there is no single way of conducting social research which is not grasped by criticisms (Denzin and Lincoln, 2005). However, Crotty (1998) and Snape and Spencer (2003) agree that conducting social research is done by a framework which explores several ways and provides guidance to minimise philosophical debates, renders methodological approach, maintains the quality of research, and secures the findings to be accepted by the readers. A number of researchers followed an approach which filters through the research paradigms, theoretical perspectives, available methodologies, and methods of gathering and analysing data (Snape and Spencer, 2003; Mullins, 2010; Guba and Lincoln, 2011). This research approach also has been justified through this process of filtering to attain an effective approach according to the context of this research.

3.3 Understanding Research Paradigms

A paradigm is the framework which describes the difference in philosophical creeds of the inquirers (Guba and Lincoln, 1994; Hathaway, 1995). The word ‘paradigm’ was initially attributed by Thomas Kuhn (Patton, 1990; Guba and Lincoln, 2011). After a decade of debates on the meanings of distinct paradigms, Egon Guba (1990) endeavoured to describe the fundamental characteristics of four distinctive paradigms i.e. Positivism, Postpositivism, Critical Theory, and Constructivism (Denzin and Lincoln, 2005).

Hathaway (1995) mentions that the diverse philosophical stances of researchers can be recognised by the concept of individual paradigms. Guba (1990) and Guba and Lincoln (1994) acknowledge that the paradigms, based on the sets of basic beliefs of the proponents, provide distinct platforms to conduct disciplined inquiry in a research process. To recognise the stance of a researcher in a paradigm, Guba and Lincoln (2005) and Snape and Spencer (2003) offered a way based on the following three attributes:

(1) the nature of ‘knowable’ or ‘reality’—*ontological*;
(2) the nature of the relationship between the researcher and the ‘knowable’ or ‘reality’—*epistemological*; and
(3) the way should be followed to investigate the ‘knowable’—*methodological*.

These three attributes are subsequently based on the responses on *ontological*, *epistemological*, and *methodological* questions to the researchers. According to Guba (1990) and Crotty (1998), *Ontology* is associated with the form of nature and reality that can be possibly apprehended. For example, if an inquirer assumes the ‘*real’* world, the ontological questions will be “*what things really are*?” and “*how things really work*”(Guba and Lincoln, 1994). Things that have “real” existence and “real” actions which are acceptable are the primary belief in terms of *ontology* (Patton, 1990; Crotty, 1998; Guba and Lincoln, 2011).

Guba (1990) mentions that *Epistemological* questions deals with the relationship between the inquirer and the things that can be known. It has been also revealed by Guba and Lincoln

(1994) that if the *ontological* position of the inquirer resides “real” reality, then the *epistemological* position is confined in an objective detachment to determine “*what things really are*” or “*how things really work*”; in other word, an objectivist implies to take a position that implies ‘real’ world is to be objective.

Many authors recommend that the inquirers need to follow a way to determine what they are intended to do (Patton, 1990; Guba and Lincoln, 1994; Creswell, 2007). The authors indicated the *methodological* questions to deal with this issue. Further, Guba and Lincoln (2011) state that once an inquirer resides in the *ontological* and e*pistemological* position already, certain factors become mandatory to be maintained. For example, a ‘real’ reality by an objectivist can be apprehended by manipulative methodology, and the methods to be used needs to be allowed by the preconceived methodology.

The basic beliefs of the distinctive paradigms based on their three positional attributes are described below:

a) Positivism

Guba and Lincoln (1994) and Hathaway (1995) acknowledge that each of the paradigms comprehends three views where the inquirers reside their positions, these are *ontological*, *epistemological*, and *methodological*. Guba (1990) asserts that the *ontological* belief system of the positivism relies on the faiths “*how things really are*” and “*how things really work*”. It has been claimed by a number of authors that, in this platform, an enquirer assumes identifiable reality and knowledge in the nature or ‘real’ world; and the *epistemological* position of a *positivist* is confined in an *objectivist* pattern of study (Hathaway, 1995; Guba and Lincoln, 2011). The authors further agree that the fundamental attribute of *objectivism* is recognised by the relationship between the ‘inquirer’ and the ‘inquired object’. According to Guba and Lincoln (1994), these two entities are treated as independent elements and will be free from any possible influences by each other.

The *methodological* state of *positivism* relies on how the investigation can be conducted without being biased and maintaining the quality of the research. According to Guba (1990), a positivist intends to control both bias and quality by following manipulative methodology and empirical methods. Guba and Lincoln

(1994) reveal that the core process of the methodology that followed by positivists is the verification of assumed reality such as *attesting hypotheses* which were preconceived according to the 'true' nature of reality. Many authors identify quantitative methods as the best example of this paradigm (Crotty, 1998; Guba and Lincoln, 2011).

b) Postpositivism

Cook and Campbell (1979) have been convinced at a point that despite the real world being driven by the existing real natural causes, it is impossible for humans to truly observe the critical truth. Guba (1990) agrees with Cook and Campbell (1979) and adds that the aim of prediction and control in a *positivism* approach is a continuous process as the positivists find difficulties to limit and adjust the impairment once it is assessed. As such, according to the authors (Cook and Campbell, 1979; Guba, 1990), *ontologically*, the positivists move from existing stance of reality to the *critical realism*, the pattern is termed as *postpositivism*, in a word, the modified version of positivism. Additionally, Guba and Lincoln (1994) and Ponterotto (2005) define *critical realism* as the 'real' reality which only possible to capture imperfectly and seemingly.

Guba (1990) notes that the *epistemological* position of postpositivists appears as modified objectivist. The author further acknowledges that assumptions are made in a way where the inquirer possibly count the findings beyond the perception of reality, such as findings may emerge from the interactions between the 'inquirer' and the 'inquired object'. According to Guba and Lincoln (1994), the validity the findings is subjected to the judgement and criticisms from the group of 'critical community. Ponterotto (2005) and Guba and Lincoln (2011) mention that the *methodological* stance in *postpositivism* is emphasised on critical multiplism where the inquirer moves towards more neutral settings such as using qualitative methods or grounded theory, as well as incorporating findings into the investigation process. For example, modified experimental or manipulative, falsification of hypotheses activities are done in this framework (Guba and Lincoln, 1994).

c) *Critical Theory and Related Ideological Positions*

Critical theory emerged in 1920s from the Institute for Social Research in Germany, mentioned by many authors (Agger, 1991; Rush, 2004; Tyson, 2006; Mustafa, 2011). Guba (1990) acknowledges that when a postpositivist postures in *critical reality*, it appears to encompass the feasible alternatives of other paradigms into the *critical theory* paradigm; this is the *ontological* state of *critical realist*. The author further asserts that the virtual reality of *historical realism* is the state of knowledge that is attributed by collective values of social, economic, ethnic, political, cultural factors can be apprehended once these attributes are organised and taken as *real*. Kincheloe and McLaren (2000) agree with Guba (1990) and further annotate that critical theory addresses the losses in other paradigms such as *positivism*. Ponterotto (2005) also suggests that in a *critical theory* approach, the hands-on value of the inquirer draws the central focus on the activity, aim, and methods of research.

Ponterotto (2005) and Tyson (2006) assert that the *epistemological* position of an inquirer in *critical theory* is *subjectivist* where constructed live experience is mediated through the historical and social context. Guba and Lincoln (1994) add that a critical theorist may step out from *realist* position; i.e. a real state of affairs may influence the value positions taken by the inquirers that also possibly may be influenced by the affair. Hence, methodologically, *critical theory* is rather *transformative* but predicting and controlling are to be continued, as suggested by Guba (1990) and Rush (2004). Guba and Lincoln (2011) outline the *methodological* position of *critical theorist* that the inquiry of *critical theory* is attributed as *dialogic* by *transactional* activity. The authors recommend that within this *transactional* nature of inquiry, it is essential to exchange dialogs between the inquirer and the subject into inquired. Numerous authors claim that in this process of inquiry, the false consciousness can be eliminated (Kincheloe and P.L., 2000; Mustafa, 2011).

d) *Constructivism*

Ponterotto (2005) marks constructivist paradigm as an alternative to the positivist paradigm in terms of perceiving realism. The author has been persuaded by the argument made by Guba (1990) and Schwandt (1994) and mentions that instead of counting single objective reality, multiple realities which are apprehendable and equally valid, and should be considered. Guba and Lincoln (1994) assert that this deviation leads the inquirers to be *relativist* in *ontological* position. The authors identified the inquirers as *transactional* and *subjectivist* position in *epistemological* platform. Numerous authors agree on the fact about the main difference of *constructivist* and *critical theorist* in *epistemological* position which is recognised by the source and process of findings, i.e. instead of emerging the findings through mediated process of social and historical context in a *critical theory*, findings are rather created in *constructivist* paradigm (Kincheloe and P.L., 2000; Guba and Lincoln, 2011; Mustafa, 2011).

According to number of authors, constructivists follow the *dialectical* and *hermeneutical* approaches with considering the individual entities' day to day life (Schwandt, 1994; Ponterotto, 2005; Guba and Lincoln, 2011) . As mentioned bay Guba (1990) and Guba and Lincoln (1994), construction of individual entities are structured and compared hermeneutically to create one or more constructions which can be attested.

3.4 Phenomenological Approach

Phenomenology was introduced by Edmund Husserl in early nineteenth era (Husserl, 1983). Lester (1998) mentions that phenomenology is the approach to identify phenomena how the actors response in a particular situation. In this way, lived experience of the actors are brought to the surface with avoiding theoretical, prejudicial, and suppositional influence (Hancock, 1998; Groenewald, 2004; Manen, 2007). Many authors highlight on the credential power of phenomenology in terms of uncovering the phenomena with higher accuracy, robustness, different factors and their effects in individual cases, growing fascination on meaning, and less affect by preconceived ideas (Moran, 2000; Holroyd, 2001; Laverty, 2003; Groenewald, 2004). Over the century, researchers used phenomenology approach to investigate in various interest areas such as actors' experiences during learning process (Ajjawi and Higgs, 2007), psychological consequence of certain disease (Holroyd *et al.*, 2001), and experience being-in-community (Holroyd, 2001), and experience being-in social work (Wilcke, 2006) which suggests to use phenomenology in both areas where the persons are being-in and self-interpretive within the society.

Despite being increasingly popular and widely used approach, Laverty (2003) argues that confusion arises while choosing between *hermeneutic phenomenology* and *phenomenology* to use in a particular research. Though the borderline between these two approaches is blurred, the authors endeavour to explain distinction in terms of *ontological*, *epistemological*, and *methodological* stances of the researchers. By discussing both *Husserlian Phenomenology* and *Heideggerian phenomenology,* it has been revealed by Kakkori (2009) and Kafle (2011) that Heideggerian phenomenology encompasses the philosophical hermeneutics where the researchers avail own techniques and procedures of applying and validating research methods. However, Husserlian phenomenology suggests to remain strict in procedure and technique even against the researchers' self-interest. Furthermore, as summarised by the authors, *phenomenology* deals with the mechanistic view of the entity or persons, i.e. the entity is considered as being-in only; whereas, *hermeneutic phenomenology* concerns that the entity or persons are being-in as well as self-interpretative. Nevertheless, different authors agree that conditions fulfilling a hermeneutical approach also can be described in terms of method rather than as methodology (Polkinghorne, 1983; Madison, 1988).

Creswell (2007), and Yin (2014) argue that a research methodology needs to address the initial research questions and must fit with the paradigmatic position including the connection with the research context. This research is focused on the social construction of the people working in the construction industry, and the experience and actions during a learning process which is very similar to the research conducted by Ajjawi and Higgs (2007) and Holroyd (2001). Hardin (2009), Gu and London (2010), Arayici *et al.* (2011), and Philp (2012) concerned that during this learning and adopting period of certain technology, people choose their self-actions to direct their fate. The primary aim of this research is to understand the culture and behaviour of the people working in the construction industry while they are adopting new generation of tools, technology and process within the projects. This is in turn, a phenomenological movement. Wilcke (2002), Kakkori (2009), and Kafle (2011) suggest the hermeneutic phenomenology as an effective approach to explore such kind of phenomenological movement in terms of culture and behaviour of the people within the environment. Additionally, the research context is persuaded to focus on the stories and belief of the participants which is an interpretative process of accessing the social life of the actors, hermeneutic phenomenology suits with the research approach than the other approaches. Hence, this researcher is convinced to use *hermeneutic phenomenology* due to the philosophical stance and suitability of the methodology in various aspects; mostly, the connection between the methodology and the other parameters such as assumptions, context, nature of apprehendable knowledge, existence and actions of the actors in certain situations, and evidently conducted studies in the similar research areas, as mentioned earlier.

3.5 Adopting and Justifying Research Design

As suggested by Creswell (2007), assumptions, paradigms and framework of a research need to be explained as clearly as it at least represents the connection and practical implications with the conducting inquiry. The author further indicates that a research design initiates with outlining the philosophical underpinnings which lead the researcher to select methodological path of the study whether it is qualitative or quantitative.

From the discussion of distinct paradigms and focus of this study, in the first sight according to the context and aspect of the research, it seems that the researcher resides in *constructivism*. Since the aim of this research is to understand the culture and behaviour of the people working in a specific industry in certain situations that represents the social construction of reality (Searle, 1995) or, in other word, social phenomena (Hancock, 1998), in this type of investigation under a particular situation, *constructivism* approach with *qualitative* study can be the practical option to carry out the study, as suggested by many authors (Patton, 1990; Guba and Lincoln, 1994; Ponterotto, 2005; Creswell, 2007).

Guba and Lincoln (2005) assert that *qualitative* study emphasises on the qualities of entities and the meanings on a particular process, and is not measured or cannot be measured by experiment in terms of quantity. Numerous authors share a common idea that a researcher posturing in *constructivism* follows *hermeneutics* style; while it is deemed that the meaning is hidden and must be extracted to the surface through a deep reflection (Schwandt, 1994; Sciarra, 1999; Ponterotto, 2005; Mustafa, 2011). Phenomenology means studying the core fact from phenomena and hermeneutics is studying the process of interpretation (Kakkori, 2009). It is difficult to differentiate between the meanings of these two words. To many authors, hermeneutic phenomenology is a type of phenomenology that includes a researcher's involvement with the process of interpretation. For example, this process includes the interactions between the researcher and the participants or the process to direct the indications of findings within the research (Wilke, 2002). When the coding is performed from the initial data (conversation through semi-structured interview), the initial codes may reflect the knowledge and background of the researcher despite been followed a systematic approach, which is unavoidable. This is one of the key reasons for that findings from a GT study through hermeneutic phenomenology are often convicted for validation by other methodology such as triangulations.

Many authors encouraged researchers to account reflexivity and explicate the process of analysing data in the qualitative research (Corbin and Strauss, 1990; Mauthner and Daucet, 2003). Accounting reflexivity and explicating the process are the vital criteria of the systematic process of collecting data and analysing them in this research. For instance, this researcher has practical experience of working in large multicultural construction projects in different countries where people from diverse organisational and socio-cultural background were present. During the research, this researcher had regular interactions with various people in the industrial and academia. These personal, industrial and socio-cultural background, and experience have obvious reflection in shaping the data that is considered in terms of social location and emotional responses of the respondents. For example, different aspects such as various interactions with colleagues and regular meetings with supervisor guided the interpretation of data such as coding and categorising and meaning of the respondents' narratives has steered the notions in the continuous process of data analysis. Coding and memo writing at various stages are documented regularly. Thus, progression with the process of analysing data, the organisation, socio-cultural and institutional reflexivity has shaped the data analysis and evolving outcomes in this research.

The researcher of this research work agrees with the suggestions made by the authors mentioned earlier and intended to undertake an in depth investigation within the particular interest areas. For instance, implementation of BIM is new to the construction industry and passing through a transitional period (NBS, 2011; Malleson, 2012), where participants respond towards the things in front of them based on the alternatives. Number of professionals and authors in the industry mention that the people in the industry now in a position to decide their destiny with their actions during the changing environment (Gu and London, 2010;

Andre, 2011; Philp, 2012). This phenomenological movement holds the similar ideology of the context of this research, i.e. an unseen shift of culture and behaviour of the people within the industry. Many authors view such kind of situation as *symbolic interaction* which is derived through social interactions (Blumer, 1980; Solomon, 1983; Nooy, 2009; Pascale, 2011), and suggested to follow *hermeneutic phenomenology* to conduct investigation (Schwandt, 1994; Sciarra, 1999; Laverty, 2003; Wilcke, 2006; Kafle, 2011). As the *ontological* and *epistemological* position of this researcher is explicated, using certain *methodology* is guided by these postures have been taken already (Guba and Lincoln, 1994). The paradigmatic posture of this research is shown in the Table 3-1.

Table 3-1: The paradigmatic position of the research

Ontological	Epistemological	Methodological	Methods
Constructivist	Subjectivist: created findings	Grounded Theory, hermeneutic phenomenological research, triangulations	Sampling, interview, comparative analysis, conversation analysis, observation, CVF analysis

As suggested by Creswell (2007) and Yin (2014), a research methodology should be selected in a way that will address the initial research questions. Also, Charmaz (2006) believes that grasping live experiences of the participants necessitates capturing multiple voices, views and ideas in the certain situations which can be achieved by Grounded Theory (GT) method. In this research, GT has been chosen to carry out in depth inquiry to apprehend live experience of the people in the particular industry which is supported by a number of authors such as Patton (1990) and Crotty (1998). The overall research potentiates a phenomenological approach through conducing GT as it is assumed in this research that the interpretations of the actors can be apprehended by examining the phenomena within the particular settings, for example, construction projects with implementation of BIM (Hancock, 1998; Lester, 1999). Thus, the research questions which underpins the culture, interactions and behaviour of the people within the industry, have been apprehended through an in-depth methodological approach of this research.

Methods used in this study have been justified through the paradigmatic position and the nature of investigation as mentioned earlier. As such, suggested by number of authors in a similar context and nature of the investigation, CVF analysis, interviews, comparative analysis, conversation analysis have been used for this study (Corbin and Strauss, 1990; Crotty, 1998; Charmaz, 2006).

3.6 Methodological and Data Triangulations in the Study

A methodological triangulation is the methodology to use multiple qualitative and/or quantitative methods in a study (Guion, 2002). According to the findings and data collected in this GT study, using quantitative method seemed to be one of the ways to validate the certainty of the findings, which is a methodological triangulation. To enhance reliability of the study process and establish validity of the findings, findings in this study have been examined through both data triangulation and methodological triangulation which includes statistical justification of the results, as suggested by many authors (Jick, 1979; Holtzhausen, 2001).

In the GT study of this research, influence of, or the relationship in between, the categories are identified. Initially, as a qualitative method, the relationships between the cultural elements of PBOs and the implementation of BIM, has been investigated through correlation test. As suggested by extant literature (Hauke and Kossowski, 2011), correlations between variables can be measured with the use of different indices (coefficients) which can be performed by various tests such as Spearman’s rank correlation coefficient and Pearson’s Product-Moment Correlation test. Pearson’s product-moment correlation test is frequently used to identify the linear relationship between the variables (Webspace, 2016). This test is also followed by the regression analysis to confirm the relationship and any possible influences of a variable to other.

However, initially with GT study, the relationship found between the categories, or the influence of a category to another, is based on the manual observation on the collected data. According to Holtzhausen (2001) and Guion (2002), such a finding in a qualitative study often convicted for reliability and validity, which demands validation of the findings through other methodology. Numerous authors suggest that findings in a qualitative study can be checked and validated through triangulation (Jick, 1979; Bryman, 2013). In this study to understand the relationship and influence of cultural elements on the outcomes in the project in terms of BIM, Pearson’s correlation test and regression analysis have been performed.

Besides identifying the cultures in various projects, cultures were identified through another source of data. The data triangulation includes collection of data by Organisational Culture Assessment Instrument (OCAI) questionnaire and bringing them according to CVF analysis to observe the state of culture in each project and the organisations involved with the projects. The methodological triangulation includes regression analysis and correlation test with the categories identified in this study.

3.7 Grounded Theory Approach: an Overview

Grounded Theory (GT) was initially introduced by Barney G. Glaser and Anselm L. Strauss in their classical publication "The Discovery of Grounded Theory" (Birks and Mills, 2010). Numerous authors claim that this methodology is one of the widely used research approach in qualitative research which enables a continual interplay between data collection and analysis leading to develop a theory (Bowen, 2006; Charmaz, 2006). It has been mentioned by Strauss and Corbin (1993) and Corbin and Strauss (1990) that in this methodology, theory is developed from the gathered and analysed data in a systematic way where data collection and analysis is a continuous process. The authors further elucidate the purpose of the continuous interplay between data collection and analysis as to verify the existing ideas and include the new ones. In the BIM-enabled construction projects, people are adopting a new process where the interactions and behaviour of the people is a continuous process towards a cultural shift. Such a phenomena demands continuous interplay between the data collection and analysis while conducting the investigation. As such, starting from zero, this researcher followed the similar approach as it was used by numerous researchers to study social construction of people as one of the major aims (Charmaz, 1983; Strauss and Corbin, 1998; Charmaz, 2008; Jones and Alony, 2011; Rich, 2012).

Over the decades, consensus has been grown on the key potential of GT methodology which is to facilitate understanding of the critical systems of social phenomena. Charmaz (1983) and Corbin and Strauss (1990) state that findings of GT study reflect the underpinning beliefs, feelings, and behaviour of the participants. It has been revealed by number of authors that in the way of conducting GT methodology, the participants take a position in the study process (Corbin and Strauss, 1990; Charmaz, 2006; Birks and Mills, 2010). The authors further believe that GT method comprises defined procedures and methods of judgement. However, it has become implied that the study of lived experience of the people need to have direct involvement with the issues, regardless it is existing or previous (Groenewald, 2004).

One of the aims of this research is to study the belief and behaviour of the people who were directly involved in BIM-enabled construction projects. Therefore, the findings of this rely on the data collected from the respondents based on their experiences and views regarding the impact of organisational culture and project culture on each other. As such, the respondents' behaviour and culture is emphasised in this study which is one of the major purposes of using GT methodology, as suggested by many authors for this approach (Glaser and Strauss, 1967; Charmaz, 1983; Corbin and Strauss, 1990).

3.7.1 Objectivist and Constructivist Grounded Theory

Heath and Cowley (2004) claim that there is a high chance of falling in a dilemma during the selection of the theory derivation approach in GT methodology whether the researcher will construct the claim trough constructivist or objectivist view. Charmaz (2004, 2008) agrees with the author (Heath and Cowley, 2004) and adds that such a dilemma can distress researchers in the core analytic process of GT if the emerging realities suggest the notions that conflict with the preconceived verifying criteria. According to Charmaz (2006), in a GT methodology, this kind of fact is revealed by the researchers while reviewing the procedure of a GT approach. The author further believes that we, the human being, do not live in a social vacuum; and, number of criticisms are often resulted from the stance of the various researchers whether it is positivist or interpretive. To minimise the scope of criticism and strengthen the claims, this researcher considers both approaches and resides the position through following understandings:

Objectivist Grounded Theory: Glaserian Classical Approach

Guba and Lincoln (1994) remark the epistemological position of a positivist as objectivist where the 'object' under investigation is considered as independent entity. The authors further highlight that the investigator studies the object in a way that either the object or investigator will not be influenced by each other. This belief recalls the perspective of Glaser and Strauss (1967) described in the publication "The Discovery of Grounded Theory" that a GT is object based and neutral. Charmaz (2006) agrees with Glaser and Strauss (1967) and Guba and Lincoln (1994, 2011) on the understanding of an objectivist researcher i.e. holding a positivist position and to remain strict with the procedure throughout the process rather than formulating the procedure to fit with the phenomena. The authors further mention that in this approach, data is considered as real, and the procedure of developing argument free from the emerging ideas and the interactions between the researcher and the participants. As asserted by Glaser and Strauss (1967), theory development in this approach is substantially based on data by making and scrutinising categories, and performing comparisons between the categories; however, keeping in mind that the theory will fit and work.

Charmaz (2006) believes that in this position of research paradigm, despite being a possibility of implementing an observational method resulting from the interactions between the researchers and the participants according to the reality, the researchers, in fact, remain detached with the actors and their realities. Glaser (2002) argues on explaining the main reason of the researcher been detained from the research participants is to maintain the data untouched by the interpretations of the researchers; especially, who are capable to redirect the inherent values inside the data. Though the foundation of grounded theory was created by Glaser, B.G. and Strauss A.L. in 1960s, later on, in 1980s, Strauss, A.L. appeared with a marginally different understanding on the procedure of grounded theory which is known as *constructivist grounded theory* (Corbin and Strauss, 1990; Strauss and Corbin, 1993; 1998).

Constructivist Grounded Theory

According to Corbin and Strauss (1990) and Charmaz (2006, 2008), a constructivist furthers the findings than the meanings inside the data. The authors further denote that this approach prioritises on the phenomena, data analysis and the shared experience between the researcher and the participants. Corbin and Strauss (1990) endorse that a researcher will examine how the actors select their action to control their destiny in a changing environment. With the acceptance of the explanation given by the authors (Corbin and Strauss, 1990), the purpose of a constructivist GT study, as clarified by Gubrium and Holstein (1997) and Charmaz (2006, 2008), is to address the answer of the questions '*how'* and '*why'* the actors make meanings in specific situations and select their action to control destiny.

Different authors mention that in this approach, the idea is taken from the evolving situation where indications from earlier data is taken into account (Strauss and Corbin, 1993; Charmaz, 2006). The authors further describe that steps are undertaken with accounting the findings from preceding step of analysis including the meanings and the actions understood by both researchers and participants. Been agreed with Corbin and Strauss (1990) i.e. researchers in constructivist GT approach become close and enter into the daily life of the actors where particular situation is taken into account, Charmaz (2008, p.402) enlists following assumptions which a constructivist GT study implies:

a) "Reality is multiple, processual and constructed—but constructed under particular conditions";
b) "The research process emerges from interaction";
c) "It takes into account the researcher's positionality, as well as that of research participants". For example, the epistemological and ontological position guided this researcher to initiate the process of data collection and analysis;
d) "The researcher and the researched construct the data—data are *product* of the research process, not simply observed objects of it". For instance, the findings account the reflexivity of the researcher's socio-cultural, industrial, and institutional backgrounds. Knowledge on research methodology from extant literature provided the necessary guideline to create the findings and pass through an attesting process for the claims through triangulations.

This research has been carried out in a way that had followed these assumptions. For instance, in practice, the social construction of a BIM project is underpinned by technology and guided through an administrated process within a common data environment. The data collection and analysis was directed though the interplay between the analysed and evolving concepts. The notions from the emerging data and the understanding of the researcher were considered to articulate the aspect of the further interviews. Thus, the data in this investigation emerged through process which is ultimately a product of few elements such as word of the participants, understanding of the researcher, and notions emerged throughout the process.

The ideological stance of this research is resided as *constructivist* that has been explained earlier. Further, the researcher of this study disagrees with the objectivist approach of GT approach suggested by Glaser and Strauss (1967), and considered the assumptions drawn by Charmaz (2008) due to paradigmatic position and context of the research. Therefore, this research process accounts the identifying problems and their influence in the research process, i.e. a *constructivist GT study* which is suggested by many authors such as Corbin and Strauss

(1990), Gubrium and Holstein (1997), Charmaz (2006, 2008), and Jones and Alony (2011), due to the implication within the similar conditions.

3.7.2 Theories in a GT Study: Substantive and Formal Theory

Glaser and Strauss (1967) state that in a GT study, a theory is generated from the data and observed phenomena within the particular area of interest. The authors divide the theories emerged in the GT studies into two categories, 1) Substantive Theory and 2) Formal theory. According to Strauss and Corbin (1998) and Charmaz (2006), a substantive theory describes the theoretical interpretation and explanation of a particular area; problems and issues are explained in a particular setting. On the other hand, a formal theory is more abstract and deals with a generic issue which is applicable within a wider area. For instance, a substantive theory explains the delimited issues within a specific area such as construction projects with specific settings (BIM-enabled projects). However, a formal theory is an abstract of several areas of substantive theories, and helps to understand the behaviour in diverse areas of construction industry.

The GT study has been carried out in construction projects settings to investigate the phenomena while a project adopt BIM throughout the delivery process. As such, the GT study within the construction project with BIM deals with the substantive theories which explain the experience and behaviour in particular situations.

3.8 Limitations and Challenges in a GT Study

Similar to the other research methods, GT has limitations. Corbin and Strauss (1990) and Charmaz (2006) agree that GT study is an exhaustive process and the product may be influenced by the researcher's ability to interpret and understanding when the researcher is the part of the study such as in the constructivist GT approach. Furthermore, Bryant (2002) argues that GT study has the methodological shortfalls which the researchers often use as an excuse of avoiding methodological issues even those are caused by researcher's blurriness on setting up objectives.

Birks and Mills (2010) claim GT approach as one of the most widely used research design. The authors further mention that the availability of a significant number of publications on the methodology of GT study has made it popular. However, despite being used widely and frequently in qualitative research, Charmaz (1983, 2006)) argues that in a different way than other methodology, in a GT study, a stress of innovation and development of new theory persists throughout the study. It has been further noticed that during a GT study, the stress works while presenting ongoing data and performing interpretation between the data (Heath and Cowley, 2004).

Charmaz (2006) adds that providing the credibility of research is another stress which persists during the presentation of results, analysis, and evolved grounded theory. This issue was accounted earlier and explained by Glaser and Strauss (1967) that during the judgement by the readers, a good description easily attract and convince the reader as he imagines that he was on the field. However, if the description does not appeal strongly to convince the reader, there is a chance of dispose away the developed theory. Many authors suggest that a researcher need to be careful in every stage of GT study such as how the questions are asked and how the description is organised to judge the credibility (Corbin and Strauss, 1990; Strauss and Corbin, 1998; Walker, 2011).

Glaser (1978) underlines that though GT study deals with the fresh ideas where the possibility of getting influenced by the ideas of the researcher from the reviewed extant literature. In contrast, Heath and Cowley (2004) argue that the nature and extent of influence depend on how the researcher perceives the content of the literature with particular interest. Further argument on this issue is also available, i.e. the influencing factors includes what extent the respondents are willing to share or where the interviews are taken (Dickson *et al.*, 2007).

Numerous authors suggest that methodological or other issues can be minimised by following the systematic approach of GT Study (Corbin and Strauss, 1990; Bryant, 2002; Hussein *et al.*, 2014). The authors further mention that a systematic approach guides the researcher in various aspects to secure a reliable process of investigation. For instance, justifying the concepts throughout the following interviews helps a researcher to identify the concepts to be discarded and brought under further justification. Such a process benefits the researcher in two ways: 1) discarding the irrelevant concepts justified through the continuous process of data collection and analysis, and 2) heading with the meaningful concepts towards emerging theory. Thus, a researcher passes through an exhaustive process with a systematic approach and confidence. However, the focus of the research is secured by discarding, accounting and justifying process of GT. Additionally, this study is conducted in a particular condition where reality is constructed through a process of multiple elements (Charmaz, 2008), such as people, construction project delivery process and application of certain technology in construction projects. This process secures a researcher from the influence of the extant literature. This study was conducted by following the systematic approaches, principles and procedures, and evaluation criteria suggested by numerous authors (Glaser and Strauss, 1967; Strauss and Corbin, 1993; 1998; Charmaz, 2006; 2008).

3.9 Criteria of GT study

Charmaz (2006) highlighted that it is important to review the GT investigation and evaluate the findings from the study. The reason behind the evaluation is to clarify the overall process of the completed study to the audiences. Corbin and Strauss (1990) further assert that it is possible to evaluate the GT study if the principles and procedures are written. For this study, the criteria, principles and procedures are explicated to ensure justification process during and end of the research.

Glaser (1978) insisted on setting up criteria of GT study for particular interest area that will fit, work, be relevant, and modifiable to help and render the data to construct a theory. This study has been conducted by following certain criteria which are suggested by Charmaz (2006). Following are the criteria which this GT study has been aimed to fulfil to make the procedure systematic and justifiable (Charmaz, 2006):

a) Credibility

- Does the study show close relationship between theoretical interpretations with the collected data in the particular setting?
- Are the evidences satisfactory in terms of variety, quantity, and depth to merit the claims?
- Do the categories allow empirical observations at a wide range?
- Were the comparisons between the categories made in an organised manner?
- Is the link between argument and data strong and logical?
- Are the evidences enough to allow the reader to perform independent judgement—finally to agree with the claims?

b) Originality

- Do the categories offer novel insights?

– Is the analysis adequate and systematic to allow new conceptual interpretation of data?
– Does the study potentiate social and theoretical significance?
– How the conducted study challenge, offer, and refine current practice, ideas, and thoughts?

During this study, collected data was justified and categorised in accordance with the extant literature which includes construction project delivery process, building information modelling, and particular setting of BIM-enabled projects. The emerged concepts were brought under comparison and discussion to build arguments and claims in terms of evolving theory. Justification, exclusion, and inclusion of new ideas were continued to cover wider range of variety and satisfactory depth of investigation. Emerging new concepts were furthered to be justified until the saturation of concepts became apparent within the context of the research in a particular setting. For example, various elements of the culture of the BIM projects and different types of interactions were justified throughout the investigation. Thus, the undertaken justification process of ideas throughout the study helped to meet the challenges in terms of *credibility* and *originality* of the investigation.

c) Resonance

– Is the entire experience of the study exhibited through the categories?
– Does the study convey both transitional and unstable self-evident meanings?
– In the study, are the links established between the larger collectivities or organisations and individual lives according to the indication of collected data?
– Does the grounded theory make sense to the people according to the situations described by them?
– In the analysis, are the deeper insights been offered to the actors about their lives and surroundings?

d) Usefulness

– Does the analysis include substantive interpretations which can be used in everyday life of the people?

- Is there any generic process that has been suggested by the systematic categories in the study? If so, is the generic process examined for tacit implications?
- Does the analysis inspire further research in other substantive areas?
- How does the study contribute knowledge? What are the pathways to impact?

Charmaz (2006) suggests that if the first two attributes (credibility and originality) are strongly maintained, it enhances the last two (resonance and usefulness) criteria of the study. This process offers better contribution in the study. Beside this, a claim needs to meticulous study of relevant literature even beyond the discipline. The author further mentions that the ultimate product depends on the researcher how he or she views the categories, organises the works and finally plots the findings and argument in an aesthetic manner. This study has been conducted in the construction projects which are currently adopting new technology. The context of the categories emerged out in this work is related to contemporary issues which are ranged widely and covers the area of interest. Data collection was continued until either justification is been done for the existing ideas or, any new concept or category was emerged and it appeared sufficient to make comparison and interpretation between the categories.

The investigation has been carried out both attending the workplaces of the respondents and over electronic media. To maintain the resonance and articulate the usefulness certain activities have been performed during the study. For example, the conversations have been carried out with the agenda of current situation in which the respondents are residing. The contextual surroundings have been considered throughout the data collection. The existing process, management, and available technical infrastructure have been considered as the integral parts of the aspects of the conversations. Perception, situation, and actions of individual respondents have been taken into account. Eventually, a broad picture has been drawn to understand the inherent phenomena within the construction supply chain while implementation of BIM is on board. The overall picture of the implementation of BIM provides a clearer understanding on the used tools, application process, and interactions of the people with new process and technology.

3.10 Explication of Principles and Procedures Followed in the Study

According to Glaser and Strauss (1967), qualitative researchers are very likely to bring the research to self-conviction after embracing the systematic approach. To attend the self-conviction process, it is necessary to explicate the overall process and principles followed throughout the study. Also, the evaluation criteria setup of the process by Charmaz (2006) necessitates explicating the principles and procedure which have been followed throughout the study. However, a different opinion also exists, i.e. canons taken by the researchers often do not discuss unless it requires verification, are retained as tacit form within the process (Popper, 1959). In this study, the cannons and procedures of conducting investigation have been made explicit.

The criteria, principles and procedures followed in this GT study is influenced by the process of conducting GT study suggested by Corbin and Strauss (1990) and Charmaz (2006). The authors elucidated the canons and procedures but keeping the method similar to the method introduced by Glaser and Strauss (1967). Corbin and Strauss (1990) further mention that though a GT study should aim to follow suggested criteria there should be flexibilities to allow procedural alteration in accordance with the unavoidable conditions of the actual project. Essential components of grounded theory followed in this study are described below:

i. Simultaneous and continuous process of data collection and analysis

The process of data collection of analysis is considered as the basic foundation of the GT study developed by Glaser and Strauss (1967). Corbin and Strauss (1990) suggest that data should be analysed once the first interview is conducted and the notions from the observations from an interview should be used as a guideline of further expectations from the next interview. The authors further endorse that the interviews should be conducted with some questions within areas of interest throughout the study until the observations from the analysis clearly indicate that the questions are irrelevant to the study or the route to the emerging theory. However, the relevant or evolved ideas must be incorporated with the questions.

According to Glaser and Strauss (1967) the systematic procedure of collecting and analysing data offers capturing all inherent relevant aspects immediately once those become apparent. Corbin and Strauss (1990) hold a similar belief and further assert that such as process fetches effectives of the approach and benefits the researcher to grasp every potential concept to build the claims. The authors suggest that a concept is initially treated as provisional and repeated in the following interviews along with the analysis and observations from different perceptions. Thus, during the analysis each concept either to be an integral part of grounding a theory, or to be rejected once it is obviously irrelevant. The process itself prevents the researcher to be biased (Corbin and Strauss, 1990; Strauss and Corbin, 1993).

A preliminary investigation was carried out among four relevant experts to articulate the initial open questions for GT study. This investigation was done to generate few ideas from zero stance of the investigation at the time period when literature on the relevant issue was very much limited. During the investigation, analysis of data in the core process of GT was done after the first interview had been taken with open questionnaire. Initially, from the open coding, various competes were emerged. All the concepts at the initial stage were noted down and notions of new theories relevant to the aim of this research were brought under justification in the following interviews. As such, aspects from the further interviews were articulated from the notions of preceding interview. Sensible concepts were continued to justify further and irrelevant concepts were rejected. This process was followed throughout the study.

ii. Concepts are the basic elements of data analysis

Numerous authors share a common procedure of conducting GT, i.e. this study is conducted with a series of steps which involve continuous comparison of data and developing concepts (Glaser and Strauss, 1967; Glaser, 1978; Corbin and Strauss, 1990; Bowen, 2006; Rich, 2012). Jones and Alony (2011) add that at this stage, data is brought under observation towards social concern according to the researcher's particular interest. Number of authors agree on a common part of the process, i.e. once the concepts are emerged from the raw data, similar concepts are to be gathered under the same label (Corbin and Strauss, 1990; Strauss and Corbin, 1998). For example, in this study, a respondent in a project stated about the project leader, "*I will say by example; he is very (very) structured*". This statement was labelled this activity as "attributes of the leader". Corbin and Strauss (1990) suggest that while moving through the interviews and analysis, similar phenomena can be brought under this basic unit of theory, and numerous concepts enable meaningful comparisons to make sense about evolving theory. In this research the attributes of the project leaders in various projects have been gathered under the concept "Attributes of the leader".

iii. Concepts must be gathered under categories to attempt identifying relationships

Corbin and Strauss (1990) and Strauss and Corbin (1998) believe that constant comparison and emerging concepts allow to initiate sensitising concepts towards theory. The authors also suggest that the similar concepts need to be grouped in individual categories by considering indication of phenomena. Rich (2012) reveals that the activity, categorisation, in a GT study offers the best way to microanalyse the categories and subcategories in terms of their properties and dimensions. For instance, in this study, comparisons between the categories have been performed. For example, during the analysis, concepts developed such as "Attributes of the leader", "Describing leadership activities", "Project leader involvement and activities", have been grouped into the category of "Leadership in a BIM project" which is finally termed as "Leadership".

iv. Sampling leads the process toward theoretical grounds

Jones and Alony (2011) suggest that immediately after coding, comparing and gathering data within the categories, the continuous process of sampling initiated in the GT study is known as *theoretical sampling*. Numerous authors agree that in this process, according to the emerging categories and samples from the continuous analysis, a researcher decides what data to be collected and which are the appropriate source of next data (Charmaz, 1983; Corbin and Strauss, 1990; Rich, 2012). As mentioned by Glaser and Strauss (1967) in their publication of the Discovery of GT study, *theoretical sampling* which distinguishes the GT study from other methodology, is a vital part of the core process of GT study. Strauss and Corbin (1993) agree with this conviction and add that in a GT study 'sampling' is done in a different way than that is done in other research methods. For instance, instead of sampling of group of individuals or units of time, it is done in terms of properties or dimensions of concepts (Glaser, 1978). It is mentioned by many authors that sampling in GT allows researcher to compare the categories in terms of properties, dimensions and variations (Strauss and Corbin, 1998; Charmaz, 2006; Sbaraini *et al.*, 2011).

On a different view, Sbaraini *et al.* (2011) suggest that in a GT study, *initial purposive sampling* is to be performed before *theoretical sampling* to implement the research design. The meaning of initial purposive sampling is the typical meaning of sampling. The authors explain that the initial purposive sampling includes identifying the population and selecting the respondents to be interviewed. For example, in this study, data was collected from the projects with different levels of BIM adoption in the construction project delivery process in various construction projects.

According to Glaser and Strauss (1967) and Corbin and Strauss (1990), *theoretical sampling* persists in the process of collecting data where aspects and ideas of successive interviews are guided by the preceding concepts and sample. The authors further acknowledge that this process is *controlled* by the notions towards the evolving grounded theory. It is also emphasised that this systematic approach of selecting both following respondents and aspects of data enables the researcher to capture the data-samples which are the most salient for the ongoing research (Jones and Alony, 2011). Accordingly, this GT study has been conducted by performing both initial purposive sampling and theoretical sampling. For example, a theoretical sampling of 'leadership' represents the *property* of the leadership such as 'behaviour of the leader'. The *dimensions* of the leadership such as 'Level of understanding and involvement of the leader on the implementation of BIM', i.e. the activities of the leader which visibly helps to implement BIM successfully and add value to the projects. These properties and dimensions have been used to identify the relationship between the leadership and other parameters in the individual projects.

v. Constant comparisons during analysis

Glaser (1978) asserts that during the selection of the comparison groups, it is necessary to account the theoretical relevance between the emerging categories to develop the theory. Corbin and Strauss (1990) suggest comparing an incident with other incidents to observe variations and similarities. The authors further recommend that as the data collection and analysis continue, the resulting concepts need to be labelled, grouped and tested with the successive data to attain more accuracy and reliability. The key purpose to carry out these activities has been described by Corbin and Strauss (1990), i.e. the constant comparisons over the time offer a researcher to identify the tiny different attributes in an original concept which allow to classify sub-divisions of the original concept; and the precision level of the study is enhanced. For example, in this research, various categories and 'level of BIM' were continually compared. At a point the 'level of BIM' was split down into two sub categories, i.e. 'Level-2 BIM' and 'value level of BIM'. As the comparison of various categories with 'level-2 BIM' was not found meaningful in terms of emerging theory or variations, comparisons were made continually with the sub category 'value level of BIM' to identify the relationship between the other categories (parameters) and level of value added in the projects through the implementation of BIM.

vi. Accounting patterns and variations

Corbin and Strauss (1990) suggest that while observing data in each step, it is necessary to record when the regularity is not in a stable state. For example, in a particular project, the team members usually provide necessary supports to build capacity and participate in teamwork, the pattern of participating in teamwork is "Capacity building within the team". In that project, if a discipline is not yet capable to undergo with the main stream due to any reason through capacity building, the part of the work to be done in certain standard by that discipline is delegated to another party within the team for a certain period in the project delivery process. The variation of the original pattern "Capacity building within the team" has been accounted during the study.

vii. Each step in the process must add precision to develop theory

Glaser and Strauss (1967) and Glaser (1978) mention that data collection in a GT study is done in a sequential way along with analysing them systematically where concepts are continually grouped and verified. Charmaz (2006) agrees with the authors and adds that it is necessary to effort enhancing precision level of the notions through continuous analysis of data in each step where emerging theory will be more précised to claim. For instance, in this research, concepts such as 'attributes of the leader' and 'project leader involvement and activities' were emerged from two different interviews and analysis, both were related to leadership. In the next interview, the information about leadership was collected in more precise manner such as the participants were asked about the level of involvement and how he behaves with the employees in terms of BIM or capacity building of the participants. At the same time, the concepts were grouped into a category 'leadership' and the properties and dimensions of this category were investigated throughout the rest of the data collection and analysis process.

viii. Reinforcing the theory development process by theoretical memos

As a general feature of GT study, numerous concepts and categories are emerged in a GT study. Glaser and Strauss (1967) and Corbin and Strauss (1990) suggest to compare, group and examine these concepts and categories continuously. However the authors mention that it becomes difficult to keep track all the categories and groups and the resulting indications. To address this issue, as suggested by many authors, memos need to be developed continually during the analytic process to characterise as *theoretical memo* by adding description and related facts towards the emerging theory (Glaser and Strauss, 1967; Charmaz, 1983; Corbin and Strauss, 1990; Charmaz, 2006). As recommended by the authors, a memo is changed throughout the process till the end in terms of content and advancing to challenge the evolving theory. A theoretical memo includes description of categories and their properties, apparent relationships and gaps. For instance a theoretical memo of the category leadership is shown in the Chapter-4:

ix. Relationships between the categories should lead to develop hypothesises which are to be vetted during the analytic process

Corbin and Strauss (1990) agree with Glaser and Strauss (1967) and assert that the relationships between the categories in each stage of analysis are plotted in theoretical memos in each stage is observed and challenged through the following analysis. According to the authors, hypothesises are developed by observing the relationships between the categories and verified during the analysis process. The authors further suggest that during this process, evidences have to be identified for both accepting and rejecting the hypotheses. For instance, in this research, the relationship between the category 'value optimisation' and 'level-2 BIM' was not found significant. However, the relationship between ‘value optimisation’ and the ‘value level of BIM’ was found apparent. As such, the comparisons show that a project leader has less influence on the ‘level-2 BIM’ and has a significant influence on the ‘value level of BIM’.

x. Overall conditions need to be considered in a broader framework

Corbin and Strauss (1990) mention that the data analysis process does not need to be restricted to the central interest and immediate phenomena. A broader structural conditions should be analysed independently with reviewing the extant literature (Glaser and Strauss, 1967; Glaser, 1978). Throughout the research, beyond the boundary of various elements of project culture and interactions between the parties, production of information through modelling process was investigated as it became relevant.

The overall data collection process was done by following the principles and procedures mentioned in the above. These were maintained to keep consistency in the whole process and link the each preceding step with the following step and bring the data into more precise level, and eventually, to ground the hidden theories.

3.11 Maintaining Quality of GT Theory Study

To maintain the quality of the study following activities through a systematic approach have been carried out:

- All the interviews were recorded and transcribed and checked thoroughly;
- Interviews were analysed immediately in each round of interview to incorporate the categories in recent phenomena with the successive interviews;
- Initial memos (case-based memos) and conceptual memos were written to capture initial ideas from literature and respondents. Progressing with the interviews, memos were continuously modified according to the phenomena captured in the interviews.
- Interviews were taken in a sequence by considering learning from earlier steps. Data analysis was carried out in each step to refine the concepts, coding, and sampling until the theoretical saturation is attained.

- Method of judgements was followed as described by Corbin, J. and Strauss, A. (Corbin and Strauss, 1990; Strauss and Corbin, 1993) and Charmaz K. (Charmaz, 1983; 2006; 2008).
- The research procedure was adjusted due to the necessity raised during the study such as the resetting the context of the following interviews as per the variations and indications from the analysis.
- Filled CVF forms were kept apart from the analytic process until theoretical saturation of categories was attained in GT study. This was done to avoid any possible bias to become pre-convinced about cultural stance of the projects during the data collection process. CVF forms were analysed along with the interviews at the core stage of analysis to develop the theory.

3.12 Inclusion of Competing Values Framework (CVF) Analysis in the Study

The research objectives are focused on the understanding of the relationship between the culture of the project-based organisations and the operation of Building Information Modelling (BIM). Therefore, the core process of the study involves understanding the culture and behaviour of the people within the construction industry while operating BIM.

During the research, an important issue came into notice that which organisation dominated the culture of a project-based organisation while operating BIM. The issue was raised when it was attempted to make the claim more evident about the relationship between the culture of the construction project-based organisations and the implementation of BIM. CVF analysis has been used to measure culture of organisations in terms of few parameters. As such, beside the GT study, to enable better understanding of the culture of the construction projects and peoples' behaviour through the investigation, Competing Values Framework (CVF) questionnaire was used to draw the cultural stances of the individual projects.

3.13 Competing Values Framework (CVF)

Competing Values Framework (CVF) is one of the most widely used tools to measure organizational culture in different aspects. It was developed by Quinn and Rohrbaugh (Quinn and Rohrbaugh, 1983).

The CVF consists of two major dimensions towards four major quadrants (see Figure 3-1 & Figure 3-2). It works as a roadmap of developing mechanism, sense-making tool, bringing new ideas, and better understanding the system (Cameron *et al.*, 2006). The first dimension of this framework varies from flexibility, discretion, and dynamism on one end towards stability, order, and control to the other end (Cameron, 2009). For example, in some organisations, managers are evaluated as effective if they have changing, adaptable and transformative characteristics. On the other hand, in some organisations, managers are assessed as effective if they are stable, predictable and consistent.

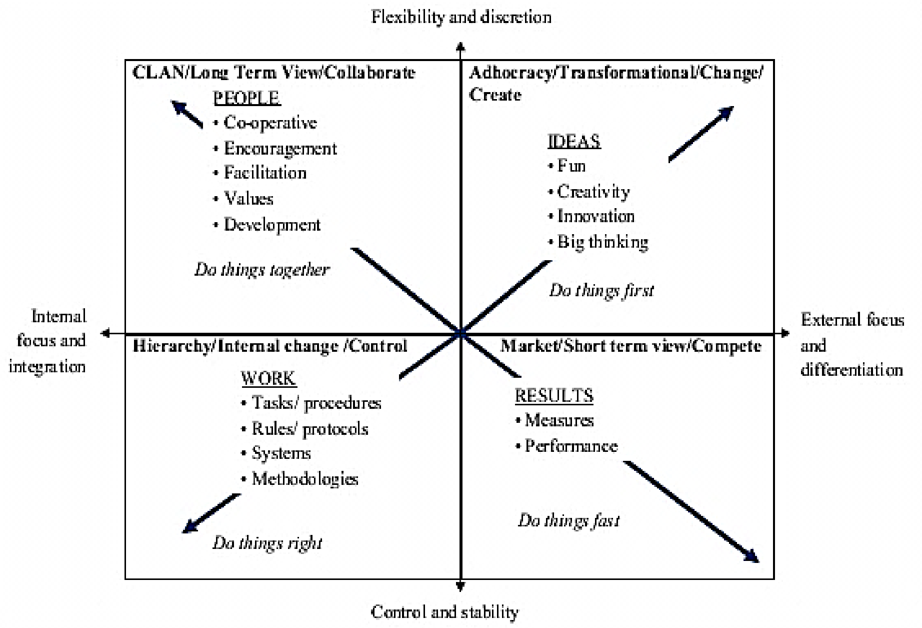

Figure 3-1: Four major dimensions of CVF

The second dimension emphasises internal orientation which focuses collaboration, integration and unity on one end, and external orientation on the other end which focuses competition, differentiation and rivalry (Cameron, 2009). The differentiation between managers with internal balanced relationships and a competitive nature to others to establish a market niche represents a good example. According to Cameron and Quinn (1999), managers of each type are viewed as effective individually in different organisations. Thus, each of the four quadrants of CVF represents distinctive organisational cultural attributes. These are i.e. Clan, Adhocracy, Market, and Hierarchy culture.

CLAN culture

The upper left quadrant of the framework represents CLAN culture (see Figure 3-2). Many authors mention that the main focus of the organisational effectiveness is bringing new ideas,

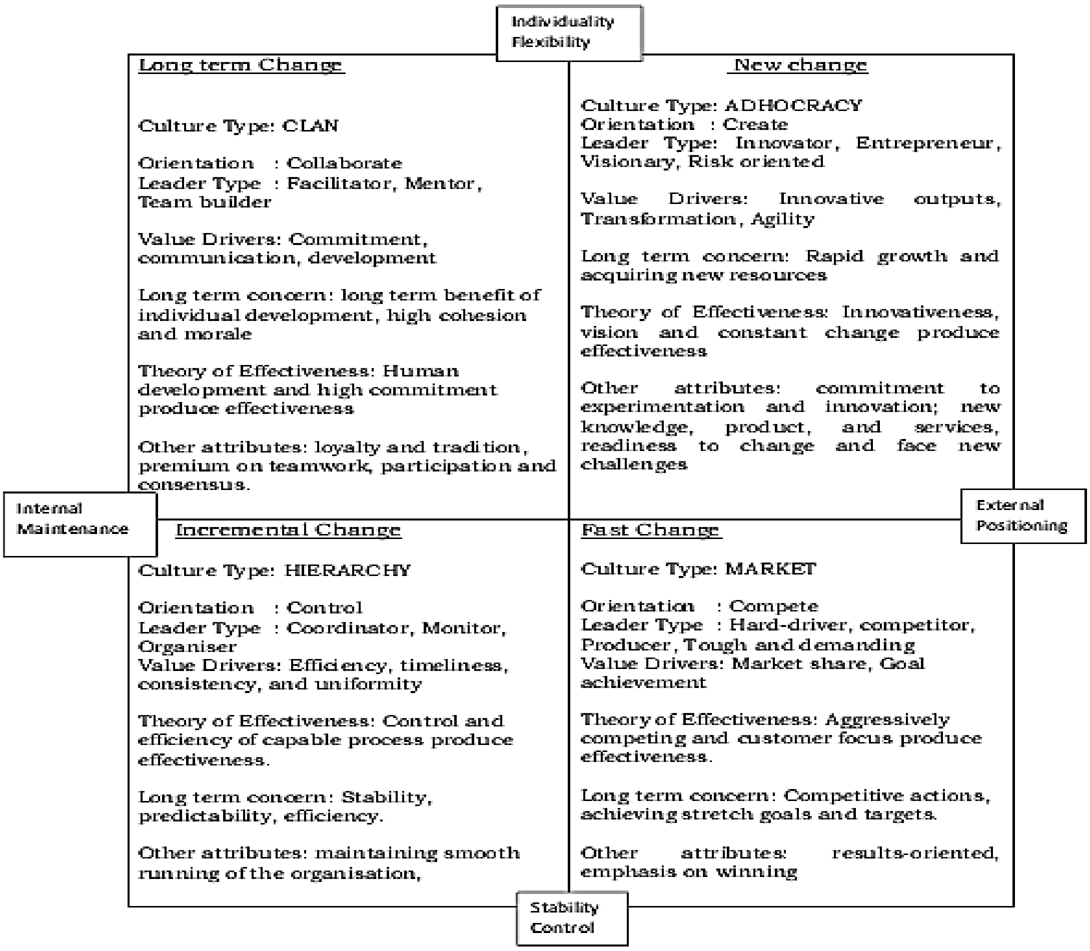

Figure 3-2: The summary of four cultures

expanding options, sharing knowledge, and collaborative learning (Cameron *et al.*, 2006; Cameron and Quinn, 2011). The organisation with clan culture is a sociable place to work where people can frequently share knowledge and ideas between each other (Cameron and Quinn, 1999).

MARKET Culture

The opposite type of clan culture MARKET culture and it is located on the opposite quadrant of the diagonal (see Figure 3-2). The key attributes of this culture is competitiveness, determination, driving through barriers, and results-oriented workplace.

ADHOCRACY Culture

The culture located on the upper right quadrant is called ADHOCRACY culture. According to Cameron and Quinn (1999), it is focused on innovation, creativity, articulating future vision, transformation change, and entrepreneurship. The organisation with adhocracy culture is dynamic and creative workplace, as mentioned by the authors.

HIERARCHY culture

The opposite diagonal quadrant shows the reverse culture of adhocracy which is addressed as HIERARCHY culture. The organisation with this culture is a formalised and structured workplace.

Construction project-based organisation is a temporary venture, where short term goal is seen in the most projects (Toor and Ogunlana, 2007). Participants work together for a certain period, and then dispersed (Arayici *et al.*, 2011). During this period, the participants become more closure and interactions become more frequent with the progress of the project. Teamwork and culture of a construction project-based organisation are different from stable economic organisations (Davis *et al.*, 1992), even it may vary project to project. Based on the context and purpose of CVF, the CVF analysis appeared to be a suitable device (by OCAI) to study the culture of project-based organisations. It is serve two purposes. These are: identifying the type cultures present within the organisations and determining the relationship between cultures of the project-based organisations and the implementation of BIM.

3.14 The Organisational Culture Assessment Instrument (OCAI)

To measure the organisational culture, specific items and steps have been suggested (Cameron and Quinn, 1999; 2011). The combined items used to assess the culture are called Organisational Culture Assessment Instrument (OCAI). Cameron and Quinn (2009) mention that the OCAI is based on the CVF and it is one of the most frequently used instruments for assessing organisational culture in different aspects. According to the authors, in general, six key dimensions of the organisational culture are assessed by this instrument. Those are, 1) Dominant Characteristics, 2) Organisational Leadership, 3) Management of Employees, 4) Organisation Glue, 5) Strategic Emphases, and 6) Criteria of Success. Each dimension consists of four alternatives (Cameron and Quinn, 2011). Culture is assessed by calculating the average of the points scored by each alternative.

CVF Questionnaire (OCAI) & Analysis

The OCAI questionnaire suggested by Cameron and Quinn (2011) used in this research is shown below (see Table 3-1):

Table 3-1 (a, b, c, d, e, and f) OCAI modified to fit for the purpose and used for the Research

(a)

	1. Dominant characteristics	Points
A	The organisation is very personal place. It is like an extended family. people seem to share a lot of themselves	
B	The organisation is dynamic and entrepreneurial place. people are willing to stick their necks out and take risks	
C	The organisation is very results-oriented. A major concern is with getting the job done. People are very competitive and achievement oriented	
D	The organisation is very controlled and structured place. Formal procedures generally govern what people do	
	Total	100

(b)

	2. Organisational leadership (Your parent organisation)	Points
A	The leadership in the organisation is generally considered to exemplify mentoring, facilitating or nurturing.	
B	The leadership in the organisation is generally considered to exemplify entrepreneurship, innovation, or risk taking.	
C	The leadership in the organisation is generally considered to exemplify a no-nonsense, aggressive, results-oriented focus.	
D	The leadership in the organisation is generally considered to exemplify coordinating, organising, or smooth running efficiency.	
	Total	100

(c)

	3. Management of Employees (Your parent organisation)	Points
A	The management in the organisation is characterised by teamwork, consensus, and participation.	
B	The management in the organisation is characterised by individual risk taking, innovation, freedom and uniqueness.	
C	The management in the organisation is characterised by hard-driving competitiveness, high demands, and achievement.	
D	The management in the organisation is characterised by security of employment, conformity, predictability, and stability in relationships.	
	Total	100

(d)

	4. Organisation Glue (Your parent organisation)	Points
A	The glue holds the organisation together is loyalty and mutual trust. Commitment to this organisation runs high.	
B	The glue holds the organisation together is commitment to innovation and development. There is an emphasis on being on the leading-edge.	
C	The glue holds the organisation together is the emphasis on achievement and goal accomplishment.	
D	The glue holds the organisation together is formal rules and policies. Maintaining a smoothly running organisation is important.	
	Total	100

(e)

	5. Strategic Emphasis (Your parent organisation)	Points
A	The organisation emphasises human development. High trust, openness, and participation persist.	
B	The organisation emphasises acquiring new resources and creating new challenges. Trying new things and prospecting for opportunities are valued.	
C	The organisation emphasises competitive actions and achievement. Hitting stretch targets and winning the marketplace is dominant.	
D	The organisation emphasises on performance and stability. Efficiency, control and smooth operations are important.	
	Total	100

(f)

	6. Criteria of Success (Your parent organisation)	Points
A	The organisation defines success on the basis of the development of human resources, teamwork, employee commitment, and concern for people.	
B	The organisation defines success on the basis of having unique or the newest products. It is a product leader or innovator.	
C	The organisation defines success on the basis of winning the marketplace and outpacing the competition. Competitive market leadership is key.	
D	The organisation defines success on the basis of efficiency. Dependable delivery, smooth scheduling, and low cost production are critical.	
	Total	100

In Table 3-2, the points A, B, C, and D have different pattern of attributes. Moving from A to B, B to C, or C to D means moving from more flexibility to less flexibility or towards strict attribute for each element of culture. Similar set of questionnaire has been used to assess culture of the project-based organisations.

Scoring OCAI

After distributing the points among the alternatives of all six items, the OCAI is to be scored to assess the organisational culture. This will be done by calculating average of each alternative response, such as, make a sum of all responses on A for six items and divide the sum by 6. Similarly, average of B, C, and D will be calculated. Once this procedure is done for the 'parent organisation', the same will be followed for the 'project'.

Plotting the OCAI for culture

Following example is given to understand the OCAI plotting:

$\sum A_n$ = 1.A+2.A+3.A+4.A+5.A+6.A; sum of the points of A alternatives in six items

Score of A $=\sum A/6$ = 31.6 (say)

Similarly,

$\sum B$ = sum of the points of B alternatives in six items;

$\sum C$ = sum of the points of C alternatives in six items;

$\sum D$ = sum of the points of D alternatives in six items;

Score of each alternative B, C, and D are calculated in the same way.

Say,

Score of B_n = 18

Score of C_n = 20.5

Score of D_n = 26.7

Plotting the scores in CVF and finding the cultural stance

Scores are marked and a plot like the following Figure 3-3 will be found. The following illustrative figure shows the existing culture according to the CVF analysis.

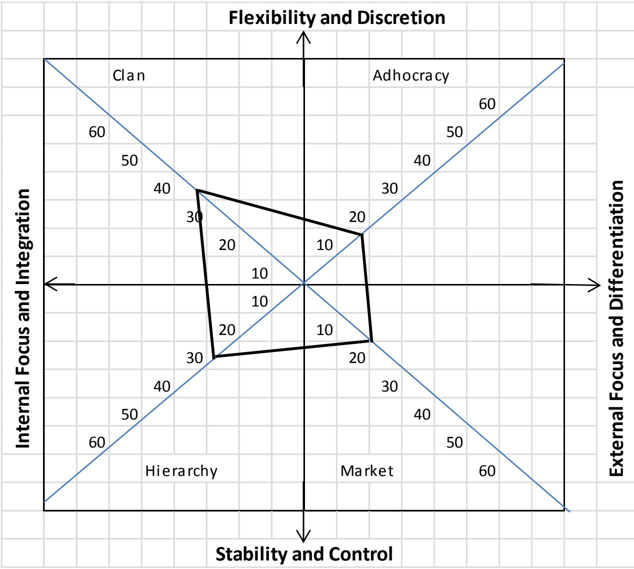

Figure 3-3: Plotting the cultural stance of the organisations

3.15 Culture, BIM, CVF, and OCAI into the Research

The call for improving efficiency by implementing BIM in the construction industry imposes change in the way of working (culture) within the project-based organisations in the whole construction supply chain (NBS, 2011). However, it is often argued that culture of organisations is invisible but inherent within the organisations (Cameron and Quinn, 2006). Many researchers point out organisational culture as a predictor of different outcomes, such as quality improvement implementation, employee and patient satisfaction, and team functioning (Helfrich *et al.*, 2007). The culture in a BIM project is a composition of diverse cultures which have been carried by the relevant contract parties. Different elements of culture in different situations predict the organisational outcomes such as effectiveness, innovation climate, and employee or customer satisfaction (Ancarani *et al.*, 2009; Alas *et al.*, 2012). Therefore, it may be useful to identify the elements of project culture through CVF analysis. The elements of culture in a BIM project include the fundamental assumptions on which the project operates, and the values that characterise the individual organisations including the project-based organisation where they are unified as a team. The CVF analysis will also enable to provide better understanding of the relationship between the operation of BIM and the cultures in various construction projects.

The core proposition of BIM is to establish collaborative project delivery process to earn the best value (NBS, 2011). However, the term ‘value’ in construction project is crucial and bears diverse meanings (Barima, 2010). Different authors (Barima, 2010; Wiewiora *et al.*, 2010) suggest that further investigation is required to understand and identify the key elements of value that are driven by diverse cultural elements of modern construction projects. BIM-enabled project is the most modernised paradigm of project delivery process and bear unique characteristic underpinned by leading-edge technology. However, adoption of BIM in project delivery process is challenging, as it involves radical change in the working culture, i.e. a significant impact on culture within the construction project organisations (Eastman *et al.*, 2011; Philp, 2012).

According to the discussions in different sections of this chapter, it has been noted that success of BIM may be influenced by the existing culture of the organisations involved in a project. Implementation of BIM involves frequent interactions of people and information, which is not present in the current practice. Hence, successful implementation of BIM demands effective project management, suitable leadership, optimum team cohesion, proper direction, and precise value proposition (Andre, 2011; NBS, 2011; Porwal and Hewage, 2013). The content and potential attributes of CVF (including OCAI) appear to be one of the possible devices to uncover the fundamental elements of BIM which drive culture in a BIM project.

3.16 Conclusion

This research design has been performed by adopting an approach considering all the alternatives in terms of research paradigms, context and position of a researcher. To conduct the study, adoptions of GT and triangulations have been explicated. The overall process includes taking interviews, transcribing and coding them and coding them to bring them into an analytic level. The practical work carried out has been described in Chapter 4.

CHAPTER 4: CONDUCTING THE RESEARCH

4.1 Introduction

This chapter introduces how the research has been conducted through the application of multi-method approach to study the implementation of Building Information Modelling (BIM) in construction projects. Starting with general ideas such as "How BIM is being implemented?" or "What happens to the culture while operating BIM?" in construction projects, a thorough study has been conducted. Observing phenomena is one of the key attentions of this study to apprehend the knowable facts. Thus, according to the paradigmatic position and the research context, this work has been conducted through GT study which encompasses hermeneutic phenomenology as discussed in Chapter-3.

4.2 Constructing the Interview Schedule

The major part of the study has been carried out through the methods followed in GT approach. The key intention of using this methodology is to find out the answers of the initial research questions and uncover the relationship between the culture of project-based organisations and the operation of BIM by maintaining consistency in techniques, procedures and the philosophical stance. Semi-structured interviews were conducted and continuously revised over furthering the interviews until the *theoretical saturation* was attained in data collection process. The respondents were selected from both BIM-enabled and traditional construction projects.

A semi-structured *interview schedule* (containing open questions) was used to carry out the interviews. The interview schedule became gradually structured throughout the process of data collection and analysis. Investigation was executed on the particular area of interest areas that cover the followings:

- Implementation of BIM in construction projects;
- Culture of construction projects;
- Influence of organisational culture on the implementation of BIM;

- Impact of BIM in the construction industry;
- The relationships and interactions between the people from diverse disciplines in the projects;
- The behaviour, beliefs and values carried by the people within the changing environment of construction project due to the implementation of BIM.

The GT study includes the following major phases:

a) Gathering data and analysis have been done through a continuous interviewing process.
b) The aspect of the following interview content was outlined in each step in accordance with the findings and notions from the preceding interviews.
c) The emerged theory and evidence based learning from the GT study have compared and interpreted with the findings of Competing Values Framework (CVF) analysis and existing literature.

Primary attempts were aimed to observe certain facts in the construction projects while operating BIM. These are given below-

- Investigating the impact on the culture of project-based organisations (PBO) due to the implementation of BIM,
- Identifying the influential factors on the success of the implementation of BIM,
- Capturing the critical relationship between organisational cultures of PBOs and the operation of BIM in the project delivery process.

From the discussions made in designing research methodology, this researcher understands that, to determine these inherent facts, a hermeneutic phenomenology would suit with conducting constructivist GT study. Perspectives on the elements such as the “meaning” or “how things are going on” in the construction projects were considered as the part of the research process. In this way, as suggested by numerous authors (Corbin and Strauss, 1990; Guba and Lincoln, 1994; Laverty, 2003; Kakkori, 2009; Kafle, 2011), this researcher became a part of the study and remained close to the participants and the phenomena. Nonetheless, extant literature has been reviewed during constructing the argument on the claims.

Numerous authors claim that implementation of BIM in the construction project delivery process requires a cultural shift within the construction industry (Yan and Demian, 2008;

Succar, 2009; Azhar *et al.*, 2011; Eastman *et al.*, 2011; Philp, 2012; Hossain *et al.*, 2013). As BIM is in a transition period in the construction industry, people within the industry are in a changing environment which triggers them to take necessary action according the things have in front of them and the meanings of the upcoming things (Blumer, 1980; MacKinnon, 2005; Nooy, 2009). As such, one of the key focuses of this study is to understand the behaviour of the people in the construction industry during the adoption of BIM in the construction projects in a changing environment where they are adopting new tools and process. The major aspects of the initial interview schedule include constructing the unseen culture of PBOs, behaviour of the people, and interactions between the parties in a construction supply chain while the supply chain is embraced by BIM.

4.3 Selection Process and Initial or Purposive Sampling

Sbaraini *et al.* (2011) assert that *initial sampling*, often termed as *purposive sampling* is one of the vital characteristics of a qualitative study. Besides, the authors mention that the purposive sample should be done in a way where the participants who can be the best persons to explain the basic concerns of the study. Groenewald (2004) impliedly agrees with the authors and adds that in a *phenomenological* approach of qualitative study, data should contain the perspective of the people who are directly involved with the particular agenda. Accordingly, this research has been undertaken by considering this fact. The sampling for this study is done by the procedure suggested by a number of researchers (Fossey *et al.*, 2002; Groenewald, 2004; Sbaraini *et al.*, 2011). The interviewed participants are connected to the BIM-enabled construction projects and a number of projects were considered to fulfil adequacy of sample for theoretical saturation, as suggested by the authors. As such, the participants are selected from the people who are directly involved with the BIM construction projects. To understand phenomena in the projects in a broad sense, projects from different sizes and locations were undertaken to conduct the investigation. All projects and the respondents are anonymised in this research due to a part of ethical consideration.

As suggested by Groenewald (2004), respondents were selected who are directly involved in a project by a reasonable capacity such as involved in the relevant field. In this research, the respondents include the people who were involved in design, management, and implementation process of BIM in the project. Interviewees involved in the construction project were from different disciplines such as architect, designer, M&E consultant or manager, civil engineer, BIM manager, BIM coordinator, planner, procurement manager, quality control; even a leading software vendor who was involved with big data management of a project was interviewed. However, as an exception case, filling CVF questionnaire was excluded for the software vendor as such a participant is not considered as a team member and has less idea about the cultural stance of the project.

4.4 Data Collection and Analysis

As suggested by Corbin and Strauss (1990), data collection has been conducted by following two primary principles. Firstly, data collection and analysis continue at the same time; secondly, the processes and the findings were resulted from both the actual data and perception on preconceived theoretical frameworks. Marshall and Rossman (1999) suggest several criteria to fulfil data collection process which incidentally follow the recommendations made by Corbin and Strauss (1990) and Charmaz (2006, 2008). Accordingly, followings have been considered during data collection of this research with considering the suggestions made by number of authors (Strauss and Corbin, 1993; 1998; Marshall and Rossman, 1999; Charmaz, 2006):

- Findings were relied on the words of the people working in the BIM projects;
- Recent data was gathered to develop concepts and meaningful questions to investigate notions from the previous data and capture new ideas;
- Interactions between the researchers and the respondents;
- Considering individual perspectives of the participants and their experience;
- Considering the individual situations to build different ideas.

These points were followed as a part of the principles and procedures to conduct GT study in a systematic manner which is described in the following sections.

4.4.1 Open Beginning and Research Questions

Numerous author suggest that relevant people are seen to utilise their different ways of guiding their destinies by their responses to the specific conditions (Blumer, 1980; Corbin and Strauss, 1990; MacKinnon, 2005; Nooy, 2009). Recommendations from these authors have been followed in this study. Thus, the preliminary assumptions are based on the unknown actions and behaviour of the participants in the construction projects, i.e. people are responding to the emerging realities during the implementation of BIM in different ways depending of various factors within the changing environment. The initial research activities were set up to identify and capture the interplay between the adoption of BIM and the actors (respondents) within the construction industry.

Initiating data collection has been carried out with interview schedule derived from literature review and preliminary interviews with number of relevant experts. The investigation with open questions includes certain interest areas such as how the organisational culture and operation of BIM influence each other, how the participants respond to the changing activities of construction project delivery process. Based on these interest areas, the major research questions were also considered to draw the aspects of the interviews.

While interviewing the people, a closed questionnaire was used to score the culture of the parent organisations of the participants and the culture of the project-based organisations. The questionnaire was the modified version of Organisational Culture Assessment Instrument (OCAI) which has been used in Competing Values Framework (CVF)(Cameron and Quinn, 1999). The OCAI was used to observe the influence of the culture of the various organisations in the culture of the relevant construction project-based organisation.

4.4.2 Overall Process of Collection and Analysis of Data

It has been suggested by Glaser and Strauss (1967) that data collection in a qualitative research should include both field and documentary data. Accordingly, field data was collected by interviews and documentary data was gathered from extant literature on the specific area and various publications from different authors and published reports. The documentary data in this research has been used to understand the emerging notions from collected data.

Respondents were communicated through different ways such as over telephone, via paper based mail, email, and by using social networks such as LinkedIn. One of the primary considerations of selecting the interviewees was bassed on the diversity of organisational backrgound of the participants in a project. For example, people from various organisations in a project were attempted to coinduct the interviews. In this way, cultures and behaviour of the people form diverse organisations gathered in a project were identified. Initially, semi-structured interviews were conducted among the participants in a BIM-enabled hospital project undertaken by one of the internationally renowned lead contractors. Data collection and analysis has been carried out together in different steps. As suggested by Corbin and Strauss (1990), Charmaz (2006) in a GT study, ideas from preceding interviews were incorporated in each following interview to sharpen the ideas and to make the claim stronger. This approach has been followed in this research. At each stage, the semi-structured interviews were transcribed and used for coding, memo writing, and configuring the concepts. The overall process of data collection and analysis in throughout the study is shown in Table 4-1.

Table 4-1: Overall process and steps of data collection and analysis

Steps of Data collection and Analysis in GT study						These two projects were also isolated as a case study
X1-P01-HW	Part-1	Part-2	Part-3			
DA-1: Transcribing, coding, emerging concepts, initial memos, adjustment of interview schedule						
X2-P01-HW	Part-4	Part-5	Part-6			
DA-2: Transcribing, coding, emerging concepts, axial coding, initial memos, adjustment of interview schedule for following interviews						
X3-P02-HA	Part-7	Part-8	Part-9			
DA-3: Transcribing, coding, emerging concepts, axial coding, mid-memos (combined memos from two projects), sensitizing concepts, few comparisons, adjustment of interview schedule						
X4-P02-HA	Part-10	Part-11				
DA-4: Transcribing, coding, emerging concepts, axial coding, sensitizing concepts, theoretical memos, comparisons, structuring interview schedule for following interviews						
X5-P03-FA	Part-12	Repeating DA-4				X1-X14: Number of steps during data collection and analysis
X6-P04-SS	Par-13	Repeating DA-4				
X7-P05-CC	Part-14	DA4+Checking for theoretical saturation = DA-5				
X8-P06-WS	Part-15	Part-16	Part-17			
Repeating DA-5						
X9-P07-TH	Part-18	Repeating DA-5				
X10-P08-DM	Part-19	Repeating DA-5				
X11-P09-SA	Part-20	Part-21	Part-22			
Repeating DA-5						
X12-P10-AI	Part-23	Repeating DA-5-Nearly theoretically saturated				
X13-P11-SF	Part-24	Repeating DA-5: Theoretically saturated				
X14-P-12-HC	Part-25	Repeating DA-5: Theoretically saturated				
P13-NON-BIM-1		Part-26	For CVF only			
P14-NON-BIM-2		Part-27	For CVF only			

X1—X14: Total 14 steps in data collection and analysis process.

P1—P14: Total 14 number of projects.

Part-1—Part-27: Total 27 number of respondents.

DA-1—DA-7: Data analysis contexts in seven gradual movements towards development of the theory.

In this research, once the data collection and analysis through initial purposive sampling had been done then the questions in the interview schedule for the further interviews were developed. Communications were made with the respondents for the further interviews. Categories were grouped and regrouped. Even further coding was done from the previous interviews according to the notions which matched with the words of the previous participants. Data was analysed on the basis of each project. For instance, categorising and coding were performed for individual projects separately and in-depth phenomena were structured individually for the projects. Figure 4-1 shows the data collection, analysis and review process towards the theoretical saturation of this GT study.

Aspects of the further interviews were adjusted according to the evolving ideas and emerging theories such as the understanding and meanings of the concepts and categories gathered from the coding, data analysis and memos. As suggested by many authors, interviews were gradually structured from open questions, modified, deleted or added accordingly (Charmaz, 1983; 2006; 2008; Sbaraini *et al.*, 2011). Simultaneously with the categories and the group of categories became sharpened, theoretical saturation were gained gradually throughout the interviews across the projects.

It has been mentioned by Charmaz (2006), along with the theoretical sampling, 'theoretical

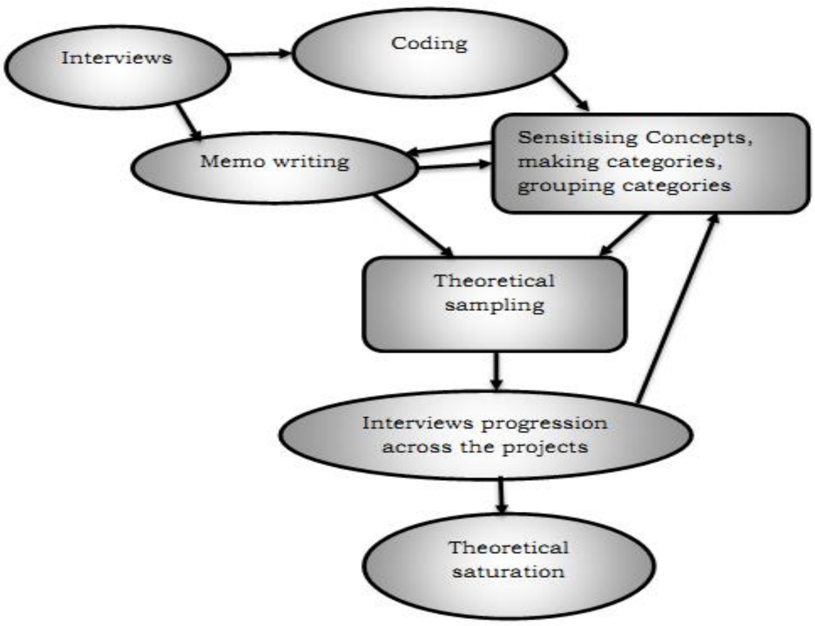

Figure 4-1: Data collection, analysis, and theoretical saturation

coding' is done in a Grounded Theory study. This is the core process of generating theory.

For example, during theoretical sampling of leadership, theoretical coding was done for the dimensions or properties of the "Leadership" such as attributes and activities of the leaders. Corbin and Strauss (1990) and Sbaraini *et al.* (2011) assert that at this stage the major focused codes are outlined. The authors further suggest that during the observation of theatrical sampling and emerging theory, individuals' perception and actions in the same situations need to be thoroughly examined and verified to examine the relationships between the categories. The summary of the process of attaining is outlined by various researchers i.e. theoretical saturation of the study is gradually attained throughout the process by repeating and rendering the coding, memo writing and theoretical sampling continuously during the interview process; eventually, grounded theories are emerged (Charmaz, 1983; Corbin and Strauss, 1990; Sbaraini *et al.*, 2011).

4.4.3 The Continuous Process of Data Analysis

Building concepts were initiated at this stage which was primarily based on the words of the participants. As suggested by Corbin and Strauss (1990) and Charmaz (2006), after the initial interviews had been conducted with the initial interview schedule, notions found from the interviews were incorporated in the open questionnaire for the following interviews. Hence, further data collection was guided through the recent findings and notions. Proceeding with data collection, variables and concepts were identified continuously and sharpened gradually. Development of theory was attempted during the data collection process. This procedure was repeatedly maintained until the theoretical saturation was attained. Coding and memo writing, and analysis were done continuously throughout the process. 14 stages of data collection were conducted until theoretical saturation was attained. The detailed process of data collection and analysis conducted in this research is shown in Figure 4-2.

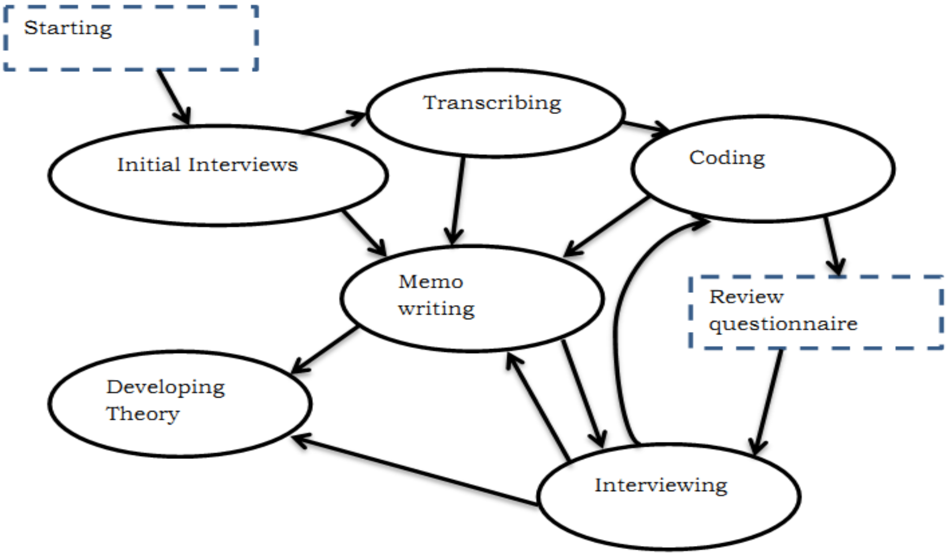

Figure 4-2: Overall data collection and analysis process

Data analysis was done by performing following activities:

Transcribing semi-structured interviews

Semi-structured interviews were conducted and recoded with the permission of each participants individually. Audio clips were transcribed word by word. The interactive interviews were configured by Nvivo software to organise data, save time and enhance accuracy within the process. The main purpose of using Nvivo software was to organise and plot a large volume of data as this software is specialised to analyse data from such kind of qualitative research. This software helped in this research in many ways such as transcribing audio clips, electronic coding from the transcripts, organising the codes, navigating among the codes for interpretation or comparison, keeping tracks. All the audio clips were carefully transcribed and organised with the help of Nvivo software to initiate coding process. All transcripts were cross-checked by competitive professionals. Figure 4-2 shows the example of transcript in the Nvivo from the audio clips before coding. Transcripts were used to enable coding from the audio clips.

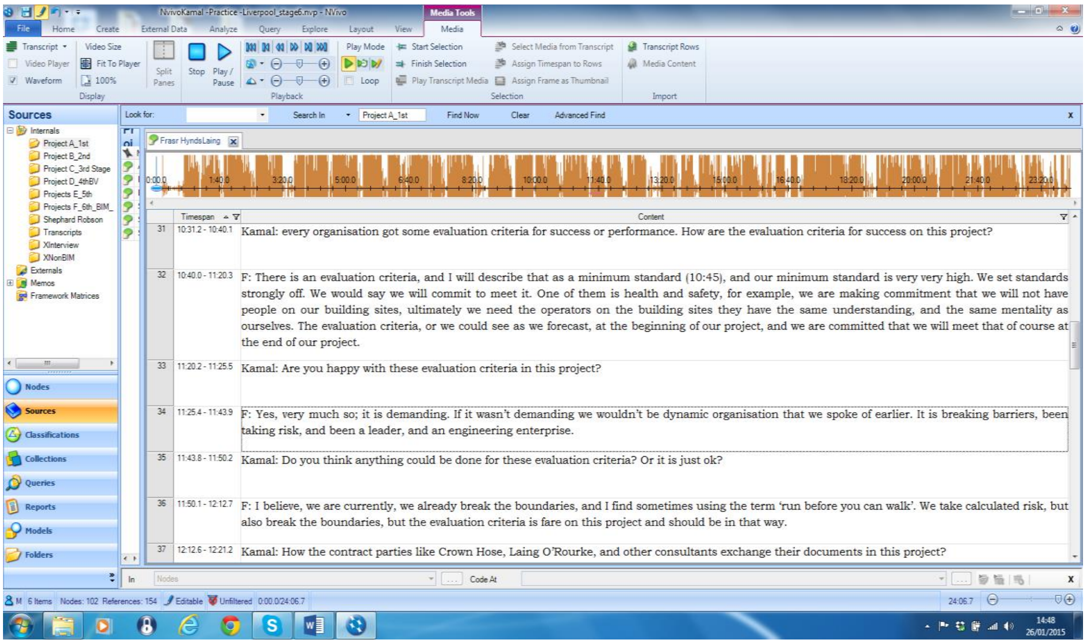

Figure 4-3: Example of audio transcript in Nvivo.

Coding from Interviews: Initiating Analytic Process

As an initial phase of analytic method, coding has been used to categorise and store data. Charmaz (1983) mentions that in a GT study, starting from zero, coding is the first activity which enables the researcher to understand 'how the people response to the specific situation or change'. The author further demonstrates that coding is the initial platform of labelling, separating, combining and synthesizing data. According to Charmaz (1983), and Corbin and Strauss (1990), in a qualitative study, there are ranges of coding used such as initial coding or open coding, focused coding, axial coding, and selective coding.

In this study, as suggested by a number of authors, coding has been done and rendered through various stages such as 'initial coding' that includes many ideas from the earlier data, 'focused coding' or 'axial coding' that includes the central codes from the entire data set (Charmaz, 2006; Sbaraini *et al.*, 2011). Numerous authors often suggest that the final categories of concepts in the emerging theory have been refined in 'theoretical coding' that was used to relate the categories between each other (Charmaz, 1983; Strauss and Corbin, 1993; 1998; Bowen, 2006). Glaser (1978) further stated that *theoretical coding* is the basic foundation for conceptualising the substantive codes to examine the relationship and integrate with the emerging theory. The stages of coding performed in this research are described below:

Initial coding or open coding

Charmaz (1983) and Corbin and Strauss (1990) suggest that once the initial interviews have been taken, initial coding should be done by selecting almost line by line of the speeches with response to the open questions in the interviews. The authors further mention that such kind of initial coding may include line by line from the transcripts. Accordingly, the initial coding process has been conducted in both during transcribing process and finished transcript of the interviews. Bowen (2006) outlines the initial coding as the starting point of emerging themes by capturing the notions and phenomena of varied situations and the responses of the actors towards the situations. Charmaz (2006) reveals that at this stage, a researcher enters to know the fundamentals of others' social life in a particular situation. It is also suggested by Charmaz (2008) that during the initial coding, to elucidate the tacit phenomena of the actors' life within the area of the researcher's particular interest, it is a primary task to examine the statements of the respondents and style of responses to the varied situations.

For creating a platform of analysing research data, Bowen (2006) suggests to sensitise the concepts. According to the author, concepts and themes are sensitised from the open codes. Corbin and Strauss (1990) add that during the open coding process, comparative analysis based on the concepts of the common elements such as actions, responses, and interactions of the actors are performed to identify similarities or differences between the elements (Corbin and Strauss, 1990). Thus, line by line of the words from the respondents have been examined to perform open coding to examine the assumptions and grasp new ideas based on the interviews. Various labels on the individual concepts were attached to distinguish and compare between them (Charmaz, 1983; 2006).

Table 4-2: Example of initial coding

Interviewee	Transcripts	Initial Coding
P01-RAF	Within the planning from itself, we can look-in at software, which links the 3D model directly to the programme.	BIM usage
P02-RAR	..the project leader operates a successful implementation there is everybody's interest in.	Activities of existing leader
P01-RSC	It is a concrete frame with prefabricated services; so, prefabricated concrete frame, prefabricated services, and just a normal fit-out with walls, floors, and ceilings.	BIM usage
P01-RSC	I think we are at Level 3.	Level of BIM
P02--RDS	He is also building services specialist so he helps in coordinating back to building services.	Characteristics of project leader
P01-RPH	…for this project is stage 4D.	BIM dimension
P02-RDS	Obviously in 5D, we can look at the cost of the building which is putting through.	BIM dimension
P02-RAR	I will set on that reference we are on level 2.	Level of BIM

From the transcripts initial coding was done randomly by selecting the words of the respondents and coded under diverse concepts. Progressing with the interviews diverse concepts were emerging and some of them were similar to the concepts of the previous interviews. Table 4-2 shows the various concepts which are labelled in the initial codes. It can be observed from the table that some of the participants directly mentioned the level of BIM but it is not clear from the statements what level they are implementing.

Initial Memo writing

Charmaz (1983) asserts that in a GT study, memo writing is the intermediate activity between coding and analysis. The author further mentions that progressing with writing memos, the data and codes move on the way to the analytic context where the notion and indication about emerging theories become gradually perceptible. Memos, not only help to fill out the concept and categorise them but also provide the explanation of the codes such as the context of the codes which help researcher to categorise the codes according to the variations and indications (Charmaz, 1983). Throughout the process of memo writing, guidelines are found about the aspects of the context of successive interviews and the particular interest area. Figure 4-4 shows an example of the initial memos of the initially emerged concepts of 'leadership' in a project.

Initial Memo/ Case based memo

Activities of existing leader

Leader in the project P01-HW is found as responsible for managing the overall project which is not much different from a typical construction project. However, the leader has more time to coordinate with the client as the information is integrated, updated and passed him on regular basis. Client's needs and changes are incorporated in the model; necessary push and support from the management is provided to the construction team. Instead of making conversation with everyone, he sets up the coordination framework and conversations are made with the people by the way he will get the best feedback.

Characteristics of project leader

According to the people from other companies, the leader of the "P01-HW" project is very much structured. When the leader initiates anything, he makes sure that the people understand what they are doing, why they are doing and what is driven into.

Figure 4-4: Initial memo for the concept of 'leadership'

Initial memos were written after the first stage of interviews was taken. As suggested by Charmaz (1983), the initial memos contained the name of the codes as topics of memos. The codes were categorised, and briefly explained in these memos. Memos were used to ask questions systematically during the interviews, considering the pre-existing ideas from the previous memos which were also explained to the participants during the interview. After few interviews, memos were brought together to make comparison in between them. The conceptual memos included the meaning of codes, thoughts about the BIM adoption process i.e. how BIM is being operated, the fundamental changes in the project delivery process, and the cultural consequences of adopting BIM.

Axial coding

Many researchers follow a common approach in GT method i.e. categorising the codes randomly based on emerging ideas through the interviews (Charmaz, 1983; Khiat, 2010; Jones and Alony, 2011). Charmaz (1983) and Sbaraini *et al.* (2011) mention this process as the next step of open coding and termed as theoretical coding. The authors highlight that this is more abstract and conceptual than open coding and number of codes are limited based on the comparison of the notions in the initial or open coding. In this way, sorting of data are brought to an analytic level based on the indications from the initial coding. This widely used approach has been used in this research. Hence, the categories were developed among the labels according to the researcher's analytic interest and research context (see the example in Table 4-3).

Table 4-3: Example of axial coding

Initial Coding / Open Coding	Axial Coding
Level of BIM	Level of BIM
BIM usage	BIM properties
BIM activities	
BIM dimension	
Characteristics of project leader	Leadership
Activities of existing leader	

Charmaz (1983) and Corbin and Strauss (1990) summarise the following purposes of focused coding in a GT method and these have been followed during the axial coding of this study:

- Building and categorising all data to cover varied situation and researcher's interest area;
- Enhancing the data at an analytic level to compare the categories;
- Breaking up the categories into subcategories to identify the variables;
- Synthesising the data to be analysed with the help of the knowledge of extant literature;
- Grounding theories from analysis;
- Structuring interpreting the data to clarify the meanings and indications by the attributes of data;
- Outlining the complexities of daily life within the researcher's interest area.

Glaser and Strauss (1967) and Corbin and Strauss (1990) believe that 'axial coding' is the initiation of 'theoretical sampling' in a GT study. The authors mention that identification of the degree of variations of the attributes of the categories needs to be attempted through theoretical sampling. This is to be done by careful comparison of the same situation of the actors across the phases of changing environment.

Theoretical coding and theoretical sampling

Corbin and Strauss (1990) mention that selecting coding is the process of unifying all the codes in different clusters which indicate meaningful notion toward developing theories. The authors further mention this process as the core process of bringing the data into theories. According to Charmaz (2006), the core activity at this stage is to bring the groups of data or codes into a platform extensive comparative study where the relationships between the categories are trialled. It is further suggested that once the comparison of core categories are performed, the other categories are taken into a process of identifying the gaps to fill in emerging theories (Charmaz, 1983; 2006). Heath and Cowley (2004) highlight this phase of the GT study as the most critical phase. The authors argue that in this phase, a tension works on the researcher while interpreting and explaining the ideas which are close to the emerging theories because of the chance of being influenced by the previous experience and existing literature during the interpretation of data.

Through the memo writing and coding process of GT approach, theoretical coding was done to conduct the observation by identifying the properties and dimensions of each entity. For example, the entity "Leadership" had been brought under observation along with the other influential entities to explore the phenomena related to this entity along with the relevant properties and dimensions. Theoretical sampling was done for each entity. Interpretation and comparison were performed among the entities with varied properties and dimensions across the projects to make the claims such as the possibility of influence of leadership behaviour and activities on the success of the implementation of BIM in the construction projects in particular conditions. Table-4-4 shows the aspects of the investigation in a theoretical sampling of "Leadership" to attain the aim of the case study. Theoretical coding was done under each of the elements of the individual entities. The data collection process was continued until the theoretical saturation of individual entities.

Table 4-4: An example of theoretical sampling of "Leadership"

Properties	Dimension(s)
Behaviour of the leader	Level of understanding and involvement of the leader in the implementation of BIM

The properties and dimensions of leadership within the projects have been explored through the investigation across the projects. For example, a project leader described himself through his own words, "*You know, myself, and design manager … had different views about how all should be implemented, this is part of the issue by the transition between normal mode operation, then changing our behaviours to suit the implementation of …(BIM). He was … releasing too much control … I am wanting tighter level of control, I did not want dying with* *responsibilities"*. This statement of the project leader indicates the understanding of the leader on the process of implementing BIM, and necessary things to be done, and the level of control the leader intends to hold during the transition period of adopting BIM, which connect with part of the elements of dimensions and properties mentioned in the theoretical coding in Table-4-4.

Theoretical memo writing is an integral part of theoretical sampling in this research. Sbaraini

Theoretical memo: Leadership

It has been observed that there is variation in in the nature of leadership in each of the projects such as in terms of level of understanding of BIM, involvement with the core process of BIM, controlling, undertaking necessary activities to comply with government mandate as well as harvest the optimum project value through BIM. According to the obtained data, the variations of the leadership context across the projects were plotted against the number of items. Each of them contains a number of specific points which were examined across the project, i.e. how the leadership of individual projects are associated with these points in terms of BIM.

Based on the aspects of theoretical coding and theoretical sampling, poetries and dimensions of leadership have been articulated. Sampling at this stage have been performed based on the word of the respondents.

Part-1: Level of understanding and involvement of the leader.

Interviewee	Transcripts	Theoretical coding/sampling	Parameters in dimensions
P01-RPH	What he does, he makes sure that people understand, what they need to know, and that's driven into… He says, "just follow", and he wants his project is on accordingly	Level of understanding and involvement of the leader	Defines roles and responsibilities/ Understands BIM with hidden value
P01-RSK	I have also used them so I have had a data rich model where your programmes, schedules and we got cost built-in.	Level of understanding and involvement of the leader	Cutting edge value proposition
P02-RAR	…the project leader operates a successful implementation there is everybody"s interest in. …in terms of BIM, the project leader makes interest to each and other reporting that and be sharing that progress been made on the project.	Level of understanding and involvement of the leader	Understands BIM with hidden value
P01-RAF	…he is basically becoming our mentor. And, we gonna have a meeting every four weeks, and basically go through what we have learned in that month.	Level of understanding and involvement of the leader	Capacity building programme in wider scale
P01-RSK	Yes, in various ways (training). I have got champions We have got a digital engineer who supports us one day a week. He comes to the site for formal training.	Level of understanding and involvement of the leader	Provides training and support to other parties
P03-RNW	So, we have successfully completed a 'BIM for Leaders" course.	Level of understanding and involvement of the leader	Participation on leadership learning on BIM

Figure 4-5: Theoretical memo and theoretical sampling of leadership

et al. (2011) suggests writing extensive 'theoretical memos' throughout the GT study. The authors mention that after each interview, case-based memos are documented which enable the explicit from of the learning from each interview. According to Charmaz (1983), these memos contain the interviewer's impressions and reactions about the participants' experiences and the detail of theoretical sampling of the entities.

In the first statement (P01-RPH), it can be seen that the participant mentions how the leader articulates the implementation of BIM and drives everyone with articulating the responsibilities. People are happy to follow the instructions as they were found happy to follow what they are asking for. The parameter of the dimension is termed as ‘*defines roles and responsibilities*’ and ‘*understands BIM with hidden value’*. In the second statement (P01-RSK), it can be seen that the leader describes his intention to implement BIM in the project to serve certain purpose. This statement clearly describes the level of understanding or involvement of the leader in the particular project in terms of the implementation of BIM. His intention is to use BIM at its highest possible capacity. The parameter of the dimension was termed as ‘*leading-edge value proposition*’. In a similar way, all the dimensions and their parameters are articulated in this research depending on the meaning according to the respondents.

Through the memo writing and coding process of GT approach, theoretical coding was done to conduct the observation by identifying the properties and dimensions of each entity. For example, the entity “Leadership” had been brought under observation along with the other influential entities to explore the phenomena related to this entity along with the relevant properties and dimensions. Theoretical sampling was done from the theoretical coding for each entity. Figure 4-5 and Figure 4-6 show the example of theoretical sampling for the

Part-2: Behaviour of the leader

Interviewee	Transcripts	Theoretical coding/sampling	Parameters of properties
P01-RSK	I am wanting tighter level of control, I did not want dying with responsibilities.	Behaviour of the leader	Controlling power and dictatorship
P01-RPH	...he is very (very) structured.	Behaviour of the leader	Controlling power
P01-RPH	…sometimes as the leader, the leader has to make decisions, has to make right decisions.	Behaviour of the leader	Sole decision maker
P02-RGC	if there is any issues so that (the project leader) process down to those kind of individuals as the leader of the project	Behaviour of the leader	Participatory decision maker

Figure 4-6: Example of property of leadership in theoretical memo

dimensions and properties of the category ‘leadership’.

It was observed that there was a variation in the nature of leadership in each of the projects such as in terms of level of understanding of BIM, involvement with the implementation of

BIM, controlling, undertaking necessary activities to comply with government mandate as well as harvest the optimum project value through BIM. According to the collected data, the variations of the leadership context in terms of BIM across the projects were plotted against the number of items (see Table 4-5). Each of them contains a number of specific points which were examined across the project, i.e. how the leadership of individual projects are associated with these points in terms of BIM. To capture all the possible items of this parameter in a BIM project, data collection process was continued until no additional or new item was found for the parameter of the particular categories throughout the study.

Table 4-5: Level of understanding and involvement of the project leader in terms of BIM

No.	**Understanding and involvement in the activities of BIM**	**Element is present (1) or not (0)**										
		P01-HW	P02-HA	P03-FA	P04-SS	P05-CC	P06-WS	P07-TH	P08-DM	P09-SA	P10-AI	P11-SF
1	Development of BIM implementation plan	1	1	1	0	1	1	1	1	1	1	1
2	Review of BIM implementation plan	1	1	1	0	0	0	0	1	0	0	0
3	Value proposition	1	1	0	0	0	1	0	1	1	1	1
4	Articulating BIM protocol	1	1	1	0	0	1	0	1	1	1	1
5	Supply chain coordination and feedback to the modelling process	1	1	0	0	0	0	1	0	1	1	1
6	Understands BIM with the hidden value	1	1	1	0	1	1	1	0	1	1	1
7	Defines roles and responsibilities of the parties clearly	1	1	1	0	0	1	0	1	1	1	1
8	Provides training and support to other parties	1	1	0	1		0	1	1	1	0	0
9	Leading-edge value proposition in terms of upcoming technology during the project execution	1	0	0	0	0	1	0	0	1	0	0
10	Capacity building programmes in wider scale	1	1	1	0	0	0	0	0	0	0	0
11	Participation in leadership learning on BIM	0	0	1	0	0	0	0	1	1	0	0
	Total score	**10**	**9**	**7**	**1**	**2**	**6**	**3**	**7**	**9**	**6**	**6**

As per the dimension of leadership in the theoretical memo, the parameter 'level of understanding and involvement of the leader' has been measured in terms of some defined criteria; some of them are shown in the Table 4-5. If one of this criteria is present in a particular project that project scores 1 point and if not present the project scores 0 for this dimension. At this point the scoring stands on a 'yes' or 'no' basis to have an idea about the overall dimensions of any parameter. Though the equality of weight of the items in the parameter is an arguable issue, the number of items present in a particular project will give a sense to assess the level of association of the leadership in the projects. For instance, a project with more scores indicates that the leadership in that project is more associated with the activities of implementation of BIM. Following Table 4-5 shows the example of scoring system on the dimension 'level of understanding and involvement' of the project leaders in various projects.

From the Table 4-5, it can be seen that the project leader in project P01-HW has the highest score as 10 on this dimension, and low scores as 1 and 2 in projects P04-SS and P05-CC respectively. This means that the leader in the project P01-HW stands at the high level of understanding and involvement in terms of implementing BIM, and the leaders in the project P04-SS and P05-CC have very low level of understanding and involvement accordingly. In Table 4-5, it can be seen that the score on understanding and involvement of a project leader in terms of BIM varies from project to project. This score stands for the dimension of leadership in the individual projects which is derived though this GT study. Hence, the dimension of leadership has been found varied across the projects. This means, the affiliation of leadership exists at different levels in various projects in terms of the implementation of BIM.

In a similar way of determining the dimensions and properties for 'leadership', dimensions and properties for the other categories have been determined through GT approach. For example, respondents were asked about the level of BIM which is under implementation in the existing projects. Some of the respondents mentioned the level of BIM as they understood from their self-perceptions. However, some of them are not keen to focus on the level of BIM to be implemented in the project. They are more willing to follow the main contractor and focus on their duties according to the relationship with the contractor and the contract agreement. For instance, in P01-HW project the participants are more focused on various activities which are set up to achieve value-based goals, instead of focusing on the level of BIM on adoption in the project. It has been found in the project that the Level-2 BIM lies within the boundaries of their objectives of the implementation of BIM. However, different respondents were opined to reach level 2 and level 3 within the same project. Hence, assessing the level of BIM implemented in a project became an arguable issue in this study.

This study has been conducted across the projects both inside and outside the UK. Participants in the projects outside the UK mentioned that BIM is not implemented at a level basis which was done in the UK. In the UK, 'Level 2 BIM' is a level of BIM which is mandated by the government and this level is not applicable for those projects outside the UK. In particular cases, in those projects outside the UK, participants became confused while they were asking about the level of BIM in their respective projects as per UK government mandate. Both inside and outside the UK, participants promptly mentioned level of BIM in terms of various activities undertaken in the projects through the implementation of BIM. Additionally, there are no standard levels of BIM available yet those can be used levels of BIM across different countries. Due to these three factors, i.e. 1) collected data from both inside and outside the UK, 2) no universal standard levels to measure level of BIM, and 3) participants reluctance to mention level of BIM, the level of BIM has been assessed based on the level of value added to the project through the implementation of BIM. The level of adding value through the activities of BIM across the projects was deduced through the GT approach. This level is termed as 'value level of BIM' for this research. An example of theoretical sampling of this dimension is shown in the part of theoretical memo in Figure 4-7.

Throughout the study, a number of items were found which add value in the projects through the implementation of BIM. Figure 4-7 shows the example of theoretical memo how value is added in a project through the activities of BIM and the value adding activities were emerged from the interviews.

The dimension of 'value level of BIM' scored in a similar way was it has been done for the 'leadership' category. The detail description of the parameters to represent dimensions of the

Value Level of BIM

The participants mention that they are trying to use the model frequently to carry out work and solve the problem with the help of BIM. Various parameter such as time lining (4D) and cost schedule (5D) is integrated with the 3D model which helps the parties to follow up time and cost, in turn which can save a lot of time and allow to have a clear idea on the expenditures on particular items. In turn, this saves a lot of time on interpretations and calculations, which is an enhancement of efficiency within the process—an additional value with the project delivery process. This means the participants can save time and cost through the implementation of BIM. Another further use of BIM is mentioned here is communicating through the model by annotations and notifications. An active and effective communication is enabled here which is adding value in the delivery process.

While client and FM team have access to the model, feedback with respect to the operational phase is received from them. FM information is attached to the model, where the benefit of the ultimate owner relies. In turn, addition of value for operation phase of the building.

Theoretical sampling of 'Value level of BIM'

Interviewee	Transcripts	Theoretical coding/sampling	Parameters in dimensions
P01-RAF	…we are trying to integrate the model, as much as we can, and if we have any coordination issues on site, we generally open up the BIM model, so that our peers can communicate around the BIM model itself.	Value level of BIM	-Integration of model (4D, 5D) -Use the model during discussions/meetings -Communicate through the model
P01-RAF	we use BIM to link BIM to the programme, and time lining	Value level of BIM	4D time lining
P02-RDS	We reference is as 4D but we also have commercial controls	Value level of BIM	4D time lining 5D cost inclusion
P01-RSC	the guys who do the drainage can come in and fly around the ground and see what clashes with the ground network with the foundations, and the management team is to review and flying around and say how we review that and how we rebuild that.	Value level of BIM	-Clash detection -Real time data transfer -Progress review (use of model in construction phase)
P02-RDS	We are trying at the moment is attaching information of the each of the products within the model so, we have got an idea. Long term FM share with this with FM management team.	Value level of BIM	Client access and coordination and inclusion of FM information

Figure 4-7: Example of theoretical sampling and memo of 'Value level of BIM'

various categories in this GT study has been given in Chapter 5.

4.5 Using Regression Analysis and Correlation Test for Methodological Triangulation

Correlation test has been performed in this study to observe whether the categories are related to each other. Pearson's product-moment correlation test has been performed in this study as mentioned earlier in Chapter-3. However, a correlation test does not prove the influence of a category to other one but the relationship between them. Therefore further analysis by regression analysis has been performed in this research.

As a part of the core process of the GT approach, comparisons between the categories (termed as variables in statistics) are performed to identify the relationship between each other. In this study, the key objectives of the comparison are to find the nature of the relationship between the variables and the influence of independent variable(s) to other dependent variable(s). For example, it has been found in this study that the 'BIM implementation plan and protocol' is a consequence of the intentions and actions of a leader who is directly associated with setting up BIM implementation plan and protocol. As found in the previous comparison, 'BIM implementation plan and protocol' is a dependent variable (termed as 'response' in statistics) which responses with the influence of 'leadership'. To determine this kind of influence of different factor(s) (independent variables) to a dependant variable, number of authors suggested to perform regression analysis (Rawlings *et al.*, 1998; Faraway, 1999). The authors further suggested that the objectives of regression analysis are-

a) prediction of behaviour of a response (dependant) based on future observations,

b) assessment of the influence of, or the relationship between, the descriptive variables in a particular situation,

c) a general explanation of the data structure.

According to the findings in this GT study, objectives, 'b' and 'c' in the above list are relevant to examine for this study. As such, regression analysis is performed with the general rules of statistics to explain the relationship between the categories and the influence of the categories on each other. Each of the regression analyses provides an output with a regression model. The regression models can be developed in two ways, a simple regression model and a multiple regression model. A simple regression model is based on one independent variable (termed as 'predictor' in statistics), for example, assessing the relationship in between, or influence of, 'leadership' (predictor) on the 'BIM implementation plan and protocol' (response). A multiple regression model is used for assessing the influence of more than one predictors to a response and the existing relationship between them as per available data. For example, assessing the influence of 'coordination and integration' and 'data exchanges and accessibilities' on the 'value level of BIM' can be done by a multiple regression analysis (see Table 4-6). In this study, both simple and multiple regression analysis have been used to enable understanding of the behaviour of responses in various probable ways. To identify the variables which are related to each other and influential within them, stepwise regression analysis has been conducted. A forward and stepwise regression analysis has been done to determine the best regression model.

All the regression analyses have been done by computer with Microsoft Excel to avoid exhaustive process of calculation and enhance accuracy by reducing human error. The computer based analysis of the model provides the necessary output parameters which are used to describe and validate the behaviour of the responses. For this study, describing the behaviour of the responses and validity of the behavioural models are done with the following parameters and rules of regression analysis (Faraway, 1999; Minitab, 2015):

R-squared value

R-squared value is known as coefficient of determination. When the coefficient of determination is used in a multiple regression analysis it is called as coefficient of multiple determination. This coefficient is a statistical measure of how close the data are to the fitted regression line. An R-squared value is the percentage of variation to the response due to the variation of the predictor in a linear model.

Hence, $R - squared = \frac{Explained\ variation}{Total\ variation}$

In other word, R-square value is the percentage of the variability of the response data around its mean. In the Figure 4-8, two fitted lines drawn from regression analysis which show R-squared value of 0.38 and 0.874 respectively (from left to right). This means, more data will fall closer to the right fitted line than that on the left. Thus, a higher R-squared value represents higher variation on the response in a model and vice versa.

In multiple regression analysis, a modified R-squared value is used for the multiple numbers of predictors. This value is called as ***adjusted R-squared value***. An adjusted R-squared value is generally lower than the R-squared value. This lower (adjusted) R-squared value means that the predictor improves the model by less than expected by chance. Figure 4-8 shows an example of different R-squared values with fitted line (source Minitab, 2015)

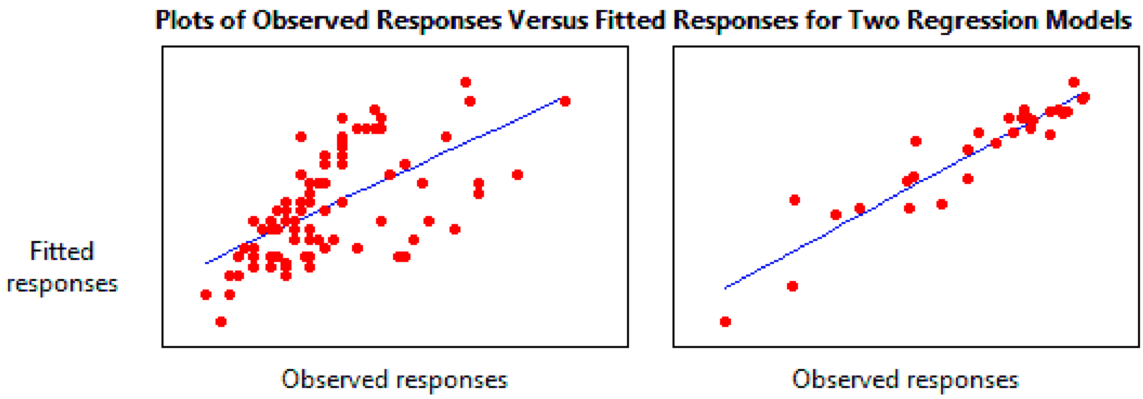

Figure 4-8: Different R-squared values with fitted line

P value

P-value is a statistical measure which is used to test the null hypotheses. Usually, this is compared with the **common alpha level** (also known as significance level) of 0.05. A significance level of 0.05 indicates a 5% risk of concluding that a difference exists when there is no actual difference. As used frequently and having wider acceptability, the common alpha level 0.05 is considered for attesting hypothesis (rejecting null hypothesis) (Minitab, 2015). Generally, if the P-value is lower than the significance level 0.05 the null hypothesis is rejected. This means, the variation in the response is significant for the variation in the predictor. The lower P-value represents the stronger relationship between the variables, and if the P-value is higher the relationship between the variables is weak. This rule is followed in the regression analysis in this study.

Significance f

Significance f is a test statistic in ANOVA test of regression analysis. The *Significance f* value is a ration of which is represented as:

$$Significance\ f = \frac{variance\ of\ the\ group\ means}{mean\ of\ the\ within\ group\ variances}$$

In ANOVA test, if the Significance f is less than 0.05 that means the explained variance is 5% less than the total variances. Thus, a lower Significance f represents higher acceptability. However, the general rule to reject null hypothesis depends on the P-value. Following example is shown to understand the regression analysis done in this study:

EXAMPLE:

In the previous example of comparison, it has been found that there is a relationship existing between the affiliation of leadership and the BIM implementation plan and protocol. Also, the categories ‘BIM implementation plan and protocol’ and ‘leadership’ have different scores across the projects. As the dimensions of these categories vary from project to project, these categories are considered as variables in this regression analysis. Intension of performing this example of regression analysis is to check the findings with within the same variables (categories) in the comparison made in the earlier example of GT study. As such the null hypothesis in this regression analysis is, ‘*the relationship between the leadership and the BIM implementation plan and protocol in a BIM project is 0’*. This means there is no relationship existing between these two categories. The data with respect to the variables across the projects are shown in the Table 4-6:

Table 4-6: Variable data of the categories

Project	BIM implementation plan and protocol	Leadership
P01-HW	8	10
P02-HA	8	9
P03-FA	4	7
P04-SS	1	1
P05-CC	1	2
P06-WS	7	6
P07-TH	2	3
P08-DM	7	7
P09-SA	7	9
P10-AI	5	6
P11-SF	4	6

The simple regression model represents the variation in BIM implementation plan and protocol due to the variation in the association of leadership in the implementation of BIM in particular projects. The summary output of regression analysis is shown in Table 4-7.

Table 4-7: Summary output of regression analysis

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.92189783					
R Square	0.84989561					
Adjusted R Square	0.833217344					
Standard Error	1.102722622					
Observations	11					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	61.96511628	61.96512	50.95827	0.00005	
Residual	9	10.94397463	1.215997			
Total	10	72.90909091				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.183932347	0.787125958	-0.23368	0.820465	-1.964534971	1.59667028
Leadership	0.848837209	0.118909638	7.138506	0.0001	0.579844919	1.1178295

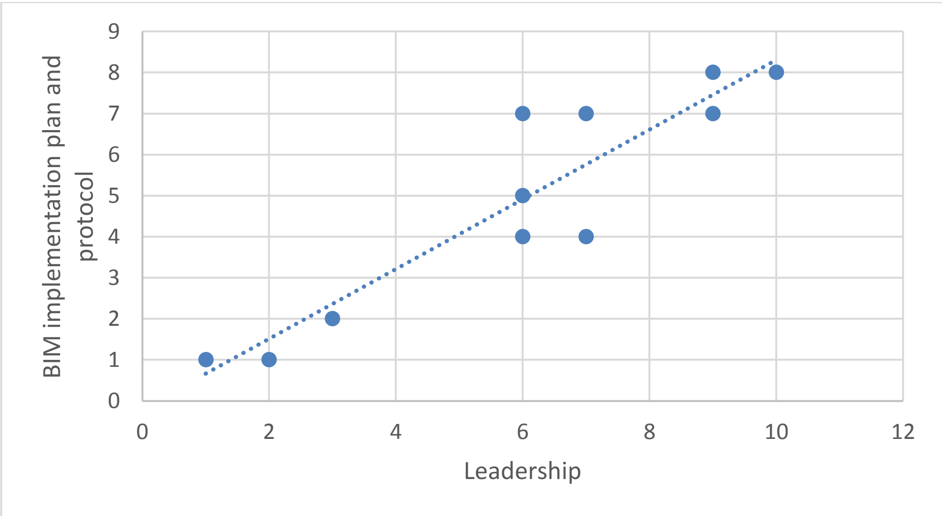

Figure 4-9: Regression line plot

In Table 4-7, it can be seen that the R-squared value is 0.84 and it is close to 1; and it can be seen in the Figure 4-9 that the variable data of the responses in the fit plot resides closer to the line. The *Significant f* is 0.00005, which is very low, hence the percentage of explained variance is very high. The P-value is 0.0001 which is lower than the common alpha level 0.05, *hence the null hypothesis is rejected*. As such, there is a relationship existing between the leadership and the BIM implementation plan and protocol in the projects. The regression model is:

*BIM implementation plan and protocol = -0.18393 + 0.848837*leadership*

The coeifficent is 0.84883. This value is closer to 1 and caries the scale in a model rather than the actual value. This means the BIM implementaiton plan is related to and influenced by the association of leadership in the implementaion of BIM. If a leader understands and involves with designing the implemetation of BIM, the precision level of the implemntation plan of BIM is enhanced. For example, various activities of BIM such as assesing and articulating the activities, responsibilities, and behaviour of the parties make a relistic and acheivable BIM impleemntation plan. As the intention of the implementation of BIM is a decision of top level management, a poject leader is desired to be undertake these activities. In the model equation, -*0.183*93 is a constant. This constant is called zero setting, and it represents the effect on the response when the value of predictor is 0. Here, the effect on the response is -0.18393 at the 0 value of leadership, i.e. BIM implementaiton plan and protocol in a project is negative when the leadership is not associated with the implementation of BIM, which is impossible. In this kind of situation, it is suggested not to interpret the value of the constant (Minitab, 2015). Addtionally, the P-value of the intercept is 0.820465 which is much more greater than the common alpha level 0.05, hence the coefficient does not bear significance at a 0 value of leadership (Minitab, 2015).

From the above observation on the regression analysis, and the comparison in the example in the GT study, it has been established that in a BIM-enabled proejct, there is a relationship between the affiliation of leadership and the BIM implementation plan and protocol, and leadership significantly infulences the BIM implementation plan and protocol.

Multiple regression analysis also has been perfomed in this study. In this process, influece of multiple variables on a signle variable has been tested. In the result, the independent variable with highest P value bears the lowest significance when it is not less than 0.05 (as discussed earlier). Then the variable is removed and regression analysis is perfomed with rest of the independent variables and the dependent variable. This process is continued until one or more than one independent variable found bearing the P value equal or less than the common alpha level 0.05.

4.6 Using OCAI Questionnaire for Data Triangulation

To understand the influence of individual organisational culture to the project culture, along with the data found in GT approach, a separate OCAI questionnaire (described in Chapter 3) was filled by the respondents to identify the cultural stance of the individual projects and the organisations involved with them. Hence, data triangulation is conducted in this study.

Conducting research work and analysing data have been carried out through the principles and procedures mentioned in Chapter 3 and Chapter 4. The results found in various projects are discussed in the next chapter (Chapter 5).

CHAPTER 5: DATA ANALYSIS AND RESULTS

5.1 General

The aim of this chapter is to illustrate the data analysis and results of this study. As a basic principle of GT study, data collection and analysis have been carried out simultaneously. The procedure of data collection and analysis are discussed in the previous two chapters (i.e. Chapter 3 and Chapter 4). This chapter will represent the followings-

- Theoretical sampling and the meaning of the included elements of each category
- Dimensions and properties of each category
- Comparison and relationship between the categories
- Brief discussions on the analysis of individual categories towards emerging theory
- Relevant entities to construct claim based on the findings.

5.2 Categories and Relationships

During the data collection and analysis process a number of concepts were emerged. The concepts were grouped into various categories. Moving from project to project, similar concepts were added with previous similar categories and new concepts were named as new categories. Some of the categories were merged when the properties and dimensions seemed to be similar; and some were used to describe various terms in the report. Following are the categories emerged throughout the research shown in Table 5-1:

Table 5-1: Categories and their interpretations

Categories	Merged with	Compared	Used in description or discarded
CT-01-BIM Properties	CT-07		
CT-02-Project Attributes			√
CT-03-Leadership in a BIM project		√	
CT-04-Data exchanges and accessibilities		√	
CT-05-Barriers of BIM			√
CT-07-Level of BIM on implementation		√	
CT-08-BIM Plan Protocol		√	
CT-09-Capacity building within the team		√	
CT-10-Transition period of BIM			√
CT-11-Change in the industry	CT-26		
CT-12-Meetings in a BIM project			√
CT-13-Communication & solving problem	CT-16		
CT-14-Oranisational cultural elements			√
CT-16-Interactions between the parties		√	
CT-17-Coordination and Integration		√	
CT-19-Decision making process			√
CT-22-Drivers fostering collaboration in BIM			√
CT-23-Evaluating success of BIM implementation			√
CT-24-Evaluation criteria for success (project)			√
CT-26-Impact of BIM in the construction industry			√
CT-27-Impact of organisational culture on BIM implementation			√
CT-28-Involvement of client with BIM	CT-43		
CT-29-IPD and BIM relationship			√
CT-30-Individual understanding of BIM			√
CT-31-Good relationship or Long-term relationship			√
CT-32-Operation of BIM	CT-07		
CT-33-Participating in teamwork			√
CT-34-Push factor and pull factor			√
CT-35-Team composition and team strength			√
CT-36-Individual involvement with the supply chain			√
CT-37-Mentioning self-role within the team			√
CT-38-Teamwork within BIM model	CT-17		
CT-39-Critical relationship between the parties			√
CT-40-Dark side of too fast technology			√
CT-41-Further action to implement BIM successfully			√
CT-42-BIM and contract agreement			√
CT-43-Optimising value of BIM		√	
CT-45-Benefits of BIM			√
CT-47-Drivers to implement BIM			√
CT-48-Frequency of communication			√
CT-49-Effort to produce information			√

In Table 5-1, the emerged categories in the GT study are listed in the first column. The categories shown in the second column is merged with the category mentioned in the first column in the same row. The categories ticked in the third column (actual categories in the first column) are compared between each other to find out the relationship between those in terms of the implementation of BIM and the culture of project-based organisations. The notions of the relationships are evolved through the continuous process of data analysis. The categories of first column which are ticked in the fourth column are discarded if those are not relevant or used to make comparison of the categories if any of those becomes relevant to the categories are ticked in the third column. Apparently, out of 48 categories, eight (8) categories are found having relationship between each other through this means of justification.

Once the categories are shaped with properties and dimensions, these have been brought under observation to investigate the relationship among the categories and any possible influence of a category to the other one. Exploring the categories with their properties and dimensions and making comparison among them are discussed in the following sections.

5.2.1 Leadership in a BIM Project (Leadership)

The project leader in this study is defined as the identifiable person who is involved in the initial phase of the project and handles designing the implementation of BIM for the whole life cycle of a project. During the data collection process, all participants were asked an open question on the project leader, "*Please tell me about the leader of this project, and how he leads the project*". Participants mentioned the relevance and authority of the project leader in terms of BIM. While the respondents were talking about the leaders in the projects it seemed that the relevant project leader has notable influence in the implementation of BIM. For example, a participant mentions, "*…the project leader operates a successful implementation (of BIM) there is everybody's interest in*". This statement shows the influence of the project leader in the implementation of BIM. Thus, comparisons and findings mostly rely on the words of the people working in the projects.

The leader in a BIM project is responsible for managing the overall project which is not much different from a typical construction project. However, in general, a project leader spends more time to coordinate with the client as it is necessary to integrate, update and coordinate information regularly. Client's needs and changes are incorporated in the model; necessary push and support from the management is provided to the construction team. The properties and dimensions of the category "Leadership" is shown in the following Table 5-2:

Table 5-2: Theoretical sampling of "Leadership"

Leadership	
Properties	Dimensions
Behaviour of the leader	Level of understanding and involvement of the leader on the implementation of BIM

It was observed that there was a variation in the nature of leadership in each of the projects such as in terms of level of understanding of BIM, involvement with the core process of BIM, controlling, undertaking necessary activities to comply with government mandate as well as harvest the optimum project value through BIM. In the collected data, the variations of the leadership context across the projects were plotted against the number of items. The process of derivation of the items has been discussed in Chapter 4 earlier. Each of them contains a number of specific points which were examined across the project, i.e. how the leadership of individual projects are associated with these points in terms of BIM. The items and points which were used to plot the leadership feature of the individual projects are stated below in Table 5-3:

Table 5-3: Understanding and involvement of the leader in terms of BIM in various projects

No.	**Understanding and involvement of the leader on the implementation of BIM**	**Element is present (1) or not (0)**										
		P01-HW	P02-HA	P03-FA	P04-SS	P05-CC	P06-WS	P07-TH	P08-DM	P09-SA	P10-AI	P11-SF
1	Development of BIM implementation plan	1	1	1	0	1	1	1	0	1	1	1
2	Review BIM Implementation Plan	1	1	1	0	0	0	0	0	0	0	0
3	Value proposition	1	1	0	0	0	1	0	0	1	1	1
4	Articulating BIM protocol	1	1	1	0	0	1	0	0	1	1	1
5	Supply chain coordination and feedback to the modelling process	1	1	0	0	0	0	0	0	1	1	1
6	Understands BIM with the hidden value	1	1	1	0	1	1	1	0	1	1	1
7	Defines roles and responsibilities of the parties clearly	1	1	1	0	0	1	0	1	1	1	1
8	Provides training and support to other parties	1	1	0	1	0	0	1	1	1	0	0
9	Leading-edge value proposition in terms of upcoming technology during the project execution	1	0	0	0	0	1	0	0	1	0	0
10	Capacity building programmes in wider scale	1	1	1	0	0	0	0	1	0	0	0
11	Participation in leadership learning on BIM	0	0	1	0	0	0	0	1	1	0	0
	Total score	**10**	**9**	**7**	**1**	**2**	**6**	**3**	**4**	**9**	**6**	**6**

From the Table 5-3, few projects have been explored for example. These include various scores such as high, medium and low scores to consider the evidence in supporting with the obtained results. The various ranges of scores are selected to give a sense what the different scores ranging from low to high influence the implantation of BIM in the individual projects. As indicated by the collected data, a desired leadership should meet the higher number of points listed in the table to functionalise a successful process of BIM.

In P01-HW project, the score is 10. Such a higher score represents how a project leader reflects his in-depth understanding of BIM, involvement, and influence through the overall process of the implementation of BIM. An in-depth understanding of a leader should result in the extensive value planning and designing the implementation for the particular project. Mentioning the project leader in this project, the respondent P01-RPH commented, "*What he does, he makes sure that people understand, what they need to know, and that's driven into, and that's up to us today up and down the line… what we would say, **leadership** things"*. This statement shows that **the project leader has comprehensive understanding on the implementation of BIM** which is reflected through his understanding and articulating certain elements such as **value aspects, responsibilities, and required logistics of the individuals**. Also, the last part of the statement supports how the existing leadership context meets the desired one. An active involvement of leadership should include clarity in understanding of the ongoing activities and association with them. A sound understanding and involvement in this project is supported by the respondent P01-RSF; and he mentioned, "*He is very knowledgeable guy, he is always tuned into what is going on*". This shows that **the leader understands the process and a close involvement with all the ongoing activities**. Consequently, such an involvement ensures conducting supply chain coordination and providing feedback to the modelling process. A participant P01-RAF mentioned, "*In terms of the overall project, he is always present there, and the information passed on we have got... So, he deals a quite a lot in terms of any client's changes or client issues, so they always getting coordinated through those meetings*". This statement shows that **the project leader is closely associated with coordination between the parties** within the supply chain and influences the preciseness of both process and product of the modelling. The leadership affiliation in this project also meets this desired point.

A respondent P01-RSC mentioned, "*You will like to say that they have their own targets to achieve but it is all managed by the project leader. So the project leader knows where the pinch points are where we need to drive to achieve another goal".* This shows that the project leader is a competent person who deals the people, process, information, and technology to implement BIM. In this P01-HW project, prior to articulate implementation plan and protocol, individuals' capacity are also assessed and the gaps are filled with necessary supports and capacity building programme. The project leader P01-RSK promptly mentioned, "*I have got champions… For the subcontractors we have got room for improvement. The subcontractors that we employ aren't there (level-2 BIM) yet"*. This shows that **the project leader offers supports to improve the capacity of the parties to a desired level** which will ensure the deliverables. This improved capacity will help in the implementation of BIM in the same project as well as in future. Thus, the associated leadership in this project meets the desired context and gained a high score, which in turn reflects through the precise implementation plan and protocol, supports and training, better coordination and integration, and healthy environment; it was seen in the project.

The leadership affiliation has a low score of 1 in P04-SS project. In this project, the project leader is neither familiar nor directly involved with operation of BIM. This situation contrasts with the desired affiliation of leadership in a project that has been found in P01-HW project. Understanding on BIM of a project leader is very important. Otherwise, both precise implementation plan and protocol will neither be articulated nor be implemented. There will be a rare chance of having positive impact of BIM in a project. This is supported by the respondent P04-RMT in the project while asking about the association of in the project. He described, "*The project leader still focuses on his job as keen as. They don't know about the BIM process they can do yet*". This statement indicates that **the project leader does not understand the value of BIM, and he is not involved with the activities** that could have positive effect on the implementation process and outcome of BIM. Negative effect of poor understanding and non-involvement of the project leader emerges out from the further statement of the respondent in the project which is, "*I am not the project manager or design manager myself, I don't know the internal strategy they are working with. It is trying to find what the end result to them, what they want from BIM process*". From this statement, it is clear that the value planning, decision making, and end result, all are significantly related the understanding and actions of the project leader. This also reveals two inconsistent pictures: a) there is no value planning or project specific implementation plan in place which should be directly embedded with the working plan of the BIM coordinator, and b) poor collaboration and integration. Thus, a poor score indicates that the level of understanding and involvement of the leader is far away from the desired context which consequences poor collaboration; the ultimate effect is a poor coordination and integration in the project.

The project P10-AI has a medium score of 6. The project leader in this project has a different view on the capacity of BIM. The project leader focuses on the ultimate product that would be achieved through BIM which is articulated at the very earlier stage of the project. For instance the project leader P10-RAD mentioned, "*I am the project leader… BIM is a contractual requirement and have been since tender. Our tender says we actually have; say, yes we are fully BIM-enabled project*". This indicates that the overall process of implementing BIM in terms of whole project delivery process is designed and shown earlier at a precise level. This also provides an idea of integrating BIM with the ultimate product at the tendering stage, which is performed to convince the clients. The earlier articulation of the implementation and product detail also has interesting result. The project leader further added, "*We actually BIM implement in our project; and we won the tender on our quality submission*". Here, the activities of the project leader enhance the reliability of his designed BIM implementation plan as well as the goal to achieve. However, having long time practice of implementing BIM, there is no capacity building programme in this project except, shadow programme to ensure the deliverables. The participants still lack for the room for improvement, and hence the score is upper medium level.

Based on the above discussions, it can be argued that a leadership with higher score means the leadership in the particular project is closely associated with the various activities implementation of BIM such as understanding, designing the implementation plan, value planning, information management, capacity building activities to ensure the deliverables in terms of BIM as well as better collaboration, coordination and integration. The better collaboration or integration removes the impediments of silo thinking of social loafing in a construction project and enhances team cohesion. A lower score, for example, in project P04-SS, represents the poor understanding and involvement with the BIM activities within the project and results poor coordination and integration. In such a project, a poor level of teamwork is developed and affects the outcomes of the whole project team.

The leadership in P01-HW project was also connected to the culture of this project. This PBO was identified as structured and lead by the leader at every level. This was expressed by a number of participates in the project. For instance, the respondent P01-RSK mentioned, "*So, we have got quite a regimented structure of how we set our stall out… a lot less dynamic*". This statement shows the cultural shape of the PBO as hierarchy. The influence of leader on the culture of the PBO is expressed in the statement of the project leader when he mentioned, "*I am wanting tighter level of control, I did not want dying with responsibilities*". This statement reinforces the evidence on the existence of influence on culture by the association of a project leader in a construction project. The association of the project leader on this project culture also can be seen from the statements of the other participants mentioned earlier. Similarly, culture can be identified in the other projects. For example, in P08-DM project, the project leader is competitive on traditional project delivery process and focuses on collaboration through the implementation of BIM. In this project, both market culture and clan culture have been found. This picture has drawn based on the statement of the respondent. For instance, the respondent P08-DM mentioned, "*He is very result driven, and motivated. So he is quite used to using a process, and I am trying to get changing his way of thinking to a different process, is a little bit harder, but you can say that we can achieve the results*". This statement shows that the leadership contributes its own culture and the implementation of BIM has notable contribution to the culture in the project. From this discussion, this is illustrated that leadership has contribution to the culture in a BIM project whereas the other factors of BIM may also drive the culture in the same project.

5.2.2 BIM Implementation Plan and Protocol

The state of BIM implementation plan for a particular project stands on the intention, requirement and existing capabilities of the various parties. The implementation plan is agreed by the parties involved in the projects at the beginning of the project. Protocols are the necessary documents used in the projects to measure or review how the contact parties are performing with respect to the agreed plan. In the projects, BIM protocol was found as various documents and forms which contain various targets on particular items. For example, a protocol document may guide the volume of information in certain format within a set up time frame. As found in various projects, BIM implementation plan provides the framework which describes extent of using the technology and kind of coordination among the contract parties.

The implementation plan must be agreed by the participants on the day-1 meeting and it varies project to project. For example, when the project P01-HW was started, there was no written protocol or guidelines published such as PAS-1192-2:2013 or BIM Protocol, the project management articulated their own protocol under Digital Engineering implementation plan. While collecting data from project to project it was found that there is a tendency of the projects which have more detail and better control on the BIM implementation plan and protocol to have better implemented BIM in the respective projects. Therefore, to compare the status of the BIM implementation plan and protocol following theoretical sampling was established (see Table 5-4):

Table 5-4: Theoretical sampling of "BIM Implementation plan and protocol"

BIM Implementation plan and protocol (Catgeory-08)	
Properties	Dimensions
Basics of plan and protocol Variety of software and capabilities of the parties Use of BIM protocol Behaviour of the parties	Sate of BIM implementation plan and protocol (Level of control to be held, and level of detail to be explored through BIM)

Basics of plan and protocol

The basics of an implementation plan found in various projects are as follows:

- Model is classed as contractual
- BIM strategy and the government mandate
- Trial basis BIM

Variety of software and capabilities of the parties

As each construction project is unique, there is no explicit protocol available which will fit for every project. It has been found that in the BIM-enabled projects, management of the project sets up the protocol based on their requirements and previous experience on the finished projects. Software specifications and related coordination are discussed during the day-1 meeting. Capabilities of the contract parties are vetted prior to start the work. Though BIM is being brought under contractual agreement still some of the participants do not use BIM frequently, they are often pulled down to the 2D drawings for further clarity in particular situations.

Capabilities of the parties within the supply chain are examined by the main contractor prior to select them. It is desired that all the parties will be working in a collaborative environment. The roles and responsibilities are drawn carefully as the parties are to be working with a live model along with the pathway to fulfil the individual and team objectives.

It has been observed that if a party is incapable to convey certain technology-driven activity, that party can be shadowed by a capable party with defined financial arrangement between the parties. Such a relationship is established by the BIM implementation plan. Also, if a party is unable to perform in the modelling process directly, another party performs the part of the job for them. Information flow between the parties and towards the BIM station is clarified through the BIM protocol.

Behaviour of the parties

Generally, in the initial implementation plan meeting which is often called day-1 meeting, all the parties meet together to set up the whole package. The detail of the whole package is not necessarily written down all time. The scopes are defined and delegated to the contract parties. Thus, the formal relationship of design coordination is established through the protocol. Each project may have unique kind of protocol depending on the nature of the project and the formal relationship between the contract parties.

Use of BIM protocol

A typical BIM protocol includes number of checklists, assessments, and necessary actions are defined in a BIM implementation protocol. The protocol also defines the capabilities of the participants and the scheme gaps within the supply chain. Capacity building programmes and training sessions are introduced within the programme of the project. The construction methodology for the particular project is agreed by the participants and the training contents are arranged considering the existing capacity and desired capacity of the individuals. The user plan falls into the BIM protocol which consists of roles and responsibilities, construction methodology, visual method of statement, data management, collaboration and clash detection. A respondent from P01-HW project commented, "…*we determine the roles and responsibilities* *we get ….with the supply chain, we review our capabilities and address scheme gaps on the stream, apply training, we got model that we agreed from a construction methodology, visual method of statement, collaboration, clash detection, all the things to address outline user plan, what are usually sent through the progress*". This shows how a protocol is developed and what things are considered to driven into. This also demonstrates the overall process and guidelines and reviewing criteria to drive and monitor the implementation of BIM.

The BIM strategy document for a particular project identifies the desired behaviour within the common platform to ensure the collaborative delivery of the project. Majority of the companies are not likely to jump into the core process of BIM from the first adventure. When they launch BIM in the construction projects, they select a project to implement BIM where there is minimum investment, less capability gap, and minimum risk. Moving from smaller project towards large project makes easier to adopt BIM at individual organisations, as claimed by the participants.

The capability gap between the small companies and the large companies may exist due to various reasons. A primary reason might be the main contractor focus on fulfilling the client's requirements which might require certain technology and information management system or infrastructure. This will incur cost for high-tech set up. As the understanding of BIM is different to different parties it is difficult to reinforce any party without ensuring the return on the investments.

Desired level of control

Level of control in a project is the production, coordination and control of documents in the particular projects. In this study, the desired mode and level of control are articulated through the following elements:

- Integration of work packages and programmes;
- Zone based control;
- Regular model update;
- Examining individual's capacities.

At first, the leading organisation draws a framework on how they can integrate work packages and programmes such as integration of phases, time line, and cost in the federated model.

Sometimes, in particular projects there are zone based integration of models which provide necessary information to the relevant parties. The zone basis control is performed to ensure the health and safety and the uninterrupted workable condition in a specific zone of the under construction project.

A regular model update provision mandates the parties to produce and deliver information at a regular time interval. However, individual capabilities are examined and necessary supports are provided to ensure the deliverables. By the examination process of a main contractor, the control level can be aimed as the capabilities of the involved parties are determined already.

Desired Level of detail to be explore through BIM

The level of detail is to be explored in a project involves the following elements:

- *Scope and responsibilities*: Scope and responsibilities of various parties in the project.
- Selecting appropriate tools: Tools are selected according to the various activities to be performed such as clash detection, offsite manufacturing, or integration of programme.
- *Meetings, behaviour and tone, collaboration approach*: The context and frequency of meetings, particular attendees.
- *Information management*: The format and volume of information to be produced by the various parties.
- *Risk management*: The assessment of potential risks and minimising them with the help of the intelligent model.

Presence of the elements of the dimensions varies project to project. Table 5-5 shows the variations of the presence of these elements across the projects:

Table 5-5: BIM implementation plan and protocol status in various projects

No.	Item	Score in projects											
		P01-HW	P02-HA	P03-FA	P04-SS	P05-CC	P06-WS	P07-TH	P08-DM	P09-SA	P10-AI	P11-SF	P12-HC
	Level of control to be held												**
1	Integration of work packages and programmes	1	1	0	0	0	1	0	1	1	0	0	
2	Zone based control	1	1	0	0	0	1	0	0	1	0	0	-
3	Regular model update	1	1	1	0	0	1	1	1	1	1	1	-
4	Examining individual's capacities	1	1	0	0	0	0	0	1	1	1	0	-
	Scores	**4**	**4**	**1**	**0**	**0**	**3**	**1**	**3**	**4**	**2**	**1**	**-**
	Level of detail to be explored through BIM												
1	Scope and responsibilities	1	1	0	1	1	1	0	1	1	1	1	-
2	Selecting appropriate tools	1	1	0	0	0	1	0	1	0	1	1	-
3	Meetings, behaviour and tone: collaboration approach	1	1	1	0	0	1	0	1	1	0	1	-
4	Information management	1	1	1	0	0	1	1	1	1	1	1	-
5	Risk management	0	0	1	0	0	0	0	0	0	0	0	-
	Scores	**4**	**4**	**3**	**1**	**1**	**4**	**1**	**4**	**3**	**3**	**3**	**-**
	Total Score	**8**	**8**	**4**	**1**	**1**	**7**	**2**	**7**	**7**	**5**	**4**	**-**

** P12-HC project is a BIM-enabled project. Data from this project is used to develop and sharpen the concepts or categories but not used for any numeric analysis throughout the study due to the lack of reliability on numeric data. The respondent is a software vendor for the project and has close association with the team but the person is not directly working with the team at site.

Scores in the Table 5-5 represents the status of the BIM implementation plan and protocol in various projects. The state of the plan and protocol describes what items are added in the plan and how those will be conducted though the implementation process in particular projects. Projects with different scores are discussed in order to understand how various ranges of scores represent the state of implementation plan and protocol and their effect on the projects.

Projects P01-HW and P02-HA received the same score of 8. At the very earlier stage of project P01-HW, BIM implementation plan and working protocol are set up and are agreed by the participants. Certain items such as updating the model, integration of work packages and programmes, names and versions of software, and behaviour of the participants within the

CDE, are defined in the implementation plan and protocol. Additionally, the detail programme of BIM is explained to the different parties up to a certain level based on the desired deliverables. A respondent P01-RSC in this project mentioned, "*What we did one is we set up a BIM protocol, how everybody work on file or information, so could all be brought together in a collaborative format, what would we work, what document management system we would use collate that, and how will we view and report against the model which is been developed… that is in our BIM protocol right to get in. We set that everybody had to use Navisworks; everybody had to use Revit 2009 and 2010*". This statement demonstrates that **the implementation plan and protocol describe the particular tools to be used and the way the parties will collaborate within the modelling process**. This also represents the detail guideline to develop the model and desired interactions between the individuals through the information model.

When parties are embraced with BIM it may not be comfortable within the working style and settings with a certain party. In that case, in project P01-HW, the leading organisation extends the hands of cooperation to provide necessary assistance for the certain party. For this project, based on the discussions on several sections, for example, 'coordination and integration' (see section 5.2.6 and relevant scores in Table-5-13), it has been observed that the coordination and integration is better in this project as it is driven by the implementation plan and protocol. Also, there is a tendency of similar pattern of variation between the scores of 'coordination and integration' and 'BIM implementation plan and protocol' across various projects. These phenomena indicate that the coordination and integration in the project is significantly influenced by the implementation plan and protocol. It can also be observed that while a BIM implementation plan and protocol in a particular project deals with the level of detail to be explored, this links the ultimate intelligent model to be used in the operation phase. Thus, the level of 'BIM implementation plan and protocol' influences the ultimate value of the project as well. From this observation, it is revealed that in this project, BIM implementation plan and protocols are set up in terms of project specific, informed, justified and extensive manner to make them achievable. This is performed in this way to make the implementation plan achievable. Eventually, the implementation plan and protocols are maintained throughout the process. Hence, this project receives a high score.

The project P03-FA gets a medium score of 5 as mentioned in Table 5-5. In this project the BIM implantation plan is in place, but a functionalised project specific BIM implementation plan and protocols did not appear from the collected data. The participants were intended to follow a protocol based on the UK government guidelines such as PAS-1192-2:2013 which does not cover the operation phase of the project. The respondent P03-RNW asserted, "*The information management procedure we following are to the government standard that is PAS-1192. We are taking part-2 approach not the part-3*". This shows that **the overall process is planned to deliver the information model in a certain way without considering the whole lifecycle of the project**. Also, the respondent's view demonstrates that the procedure of information management which is the core part of the modelling process is articulated as general guideline from the government authority. It has not been made as project specific. In this project, the model updates are mentioned, management of information is explicated, process of mitigating risk are described, and the desired behaviour of the participants are described. The consequence of a limited implementation plan and protocol in this project is the extent of coordination and integration which goes up to a certain level. This is supported by the respondent, and he mentioned, "*The bit that hasn't been organised and isn't done that I recommended which is 4D planning approach which could have been systematic site approach*". This statement clarifies that **there are few coordination and integration activities could be done or value could be added through BIM**. However, these have not been performed extensively in this project. According to the items discussed here, this project falls into a medium level of BIM implementation plan and protocol. This is also reflected in the consequence and score of this project.

Two other projects P04-SS and P05-CC receive the lowest score of 1 as mentioned in the Table 5-5. In these projects, BIM implementation plan is in place with mentioned scopes and responsibilities of the participants. However, these are not functioning properly. A participant P04-RMT in project P04-SS mentioned, "*No, unfortunately those still don't in the site or the companies, you know trying to get information flow, and when the information is been produced as well. Because a lot of guys and a lot of designers are, we do still build of 2D drawings; so, the end of the day, deliverable to us as a company*". This statement highlights that **the implementation plan and protocol is not in function in this project**. The overall feature of both projects describes the poor status of BIM implementation plan and protocol which failed to achieve the targets within the projects. This is supported by the further statement of the participant when he said, "*You know trying to get information flow, and when the information is been produced as well. Because a lot of guys and a lot of designers are, we do still build of 2D drawings*". This statement shows the inconsistent picture of the achievement in terms of information management and value addition in the project. The overall feature of the implementation plan and protocol in this project describes the story behind the poor score.

The overall discussion of the projects mentioned above indicates that a better score in particular project represents the presence and active functions of the BIM implementation plan and protocol at a higher level; and the poor score represents the opposite. A medium level score represents the current status such as presence of few items and their functions but not at an extensive level. Therefore, the scores are justified through the features and stories behind the respective projects in terms of the BIM implementation plan and protocol. This also indicates the presence of links with the coordination and integration as well as with the value achievement in the respective projects. Thus, a realistic implementation plan and protocol reflects in the outcomes in the BIM project. Also, the technical barriers or skill gaps are accounted and minimised through the BIM implementation plan and protocol. For instance, a respondent P03-RFA mentioned, "*We gonna apply at nearest down at PAS-1192; no matter the size of the project. If we do have project which is so small, they feel they don't need to touch this. But what we are trying to do is current common behaviour through the business and with our relationships, that's PAS-1192. If we can achieve doing that I think, the languages we share and the process we share will become common practice; and therefore, embedded and don't need to further that as much*". This statement shows that the implementation plan and protocol set up the team intention to deliver the project information in a certain standard which is embedded in the implementation plan. Also, the team is intended to perform the necessary activities to achieve the goal. Hence, BIM implementation plan and protocol have influence on the outcomes of the projects and the team intention on deliverables, i.e., how the team will work on a common goal or what level of collaboration will be operated in the project underpinned by BIM.

5.2.3 Optimising Value of BIM (Value Optimisation)

Implementation of BIM is new to the construction industry. It has been found that it is still in trial phase to extract value in some projects. Some of the organisations implement BIM in the projects purposely to get benefit from the leading-edge technology. In those projects, the functional parties produce the models and try to fit with the site and manage site works at the same time such as everything is same in the model as the sites have. Initially, in particular projects, it was found that the model developers assess the undertaken project and find the scope of using 3D models. Then the next step is to find the right software. The models are produced. It is important to know how parties intend to use the model in their daily works. The overall objectives are featured in the BIM implementation plan. In the implementation plan, the value planning is articulated in some projects where the participants identify the optimal potential scopes of utilising BIM to get desired benefit. Optimising potential value of BIIM in a particular project helps the multi-functional parties to realise the investment on the new technology and process. To observe how the parties plan to optimise value in BIM projects, following theoretical sampling has been performed (see Table 5-6):

Table 5-6: Theoretical sampling of "Optimising Value of BIM"

Optimising value of BIM (Catgeory-43)	
Properties	Dimension(s)
Potential areas for adding value	Number of items considered to create value

Potential areas for adding value

Potential areas for adding value are identified in a BIM project with respect to the volume and complexity of the particular project. Though most of the respondents believe that in a construction project delivery process, the major potential value of BIM relies on the design coordination process. Three projects (P01-HW, P02-HA, and P10-AI) were found where the participants use BIM extensively in the procurement process. The activities which are performed in the **procurement** process through BIM are as follows:

- *Sorting different package for procurement*: The procurement department identifies the scope of using BIM by scrutinising the work packages according to the level of complexity. For example, painting work packages or cleaning services during construction including removal of debris are left out of BIM implementation plan.
- *Item split down for tendering*: After the identification of the items, individual work packages are to be split down to prepare precise tender documents.

- *Subcontractors use model to save time*: Subcontractors use the 3D model from the lead contractor. In this way, the subcontractors do not require to visit the site to take measurement or check any other coordination issues. Each of the functional components of the building can be verified through clash detection with the other functional components. With the help of 3D information model, both the lead contractor and subcontractors can save time and money.
- *Enhance level of detail and volume of information to reduce unexpected cost:* The level of detail and volume of information is determined to ensure accounting every item in the estimate to reduce the unexpected cost at the end of the project. For example, in the previous projects of the organisation without BIM, fire stops incurred much higher cost than the estimated contingency, which caused impact on the overall profit. By using the model, with rehearsals for fire test, the accurate number of fire stops can be determined. Performing the rehearsal or splitting down the components from the work packages costs extra but that cost is included in the early estimate. This activity finally minimises the infuriating extra cost at the end of the project.

Design coordination is the most important activity in BIM where the major part of the value is deeply hidden. All the information are to be uploaded to a central server rather than exchanging between each other. Time and effort of coordination between the disciplines are saved through the configuration of design coordination. Followings are the potential scopes of value which are frequently found in the design coordination of various projects:

- *Reducing clashes*: Reducing clashes between the functional elements in a building is the most desired value in a BIM project.
- *Assessing progress by real time data transfer to save time and increase accuracy*: Linking models via Syncro is not an easy job; it was described by a respondent. However, they believe that if they do it once it will be easier for next time, so that, someone does it for the best interest of the project as well as organisation. In this activity, people fly around in the project and transfer real data to the computer with GPS Synchronising. Necessary supports and trainings are provided from the top level management to perform this job.

- *Integration of time line*: Integration of time line with the 3D model enhances the level of the model to 4D. With 4D integration, progress monitoring can be facilitated in the project. Diverse functional parties can view the progress of the project via server with visual effect, whether any particular items is completed or not.
- *Integration of cost schedule*: Cost schedule is integrated with the model as 5D and open to certain personnel in the project. For example, with an access to the cost schedule integrated model, relevant people and the client can see the actual progress and the amount spent up to a certain time in the project.
- *Coordination in a common data environment to reduce time and effort, enable seamless information flow*: CDE is an environment where all the parties reside virtually in a single premise.
- *Developing Configuration Management (CM) value*: The elements such as producing CM value and as-built model are discussed and articulated earlier. For example, the planners will draw a plan how and when to prepare as-built model and CM value and handover to the client.
- *As built drawing through the design coordination process*: As built drawing are prepared with the progression of the model as all the changes are incorporated in the model regularly and uploaded to the server. Relevant people also perform the changes accordingly. Thus, the as built drawing is prepared with the progression of the 3D model.
- *Reviewing construction procedure*: Construction procedure can be reviewed by viewing the virtual procedure of the construction procedure and sequence with the help of computer simulation. The overall construction process can be viewed by performing rehearsals. Also, the potential constructability difficulties and hazards can be identified in this way.
- *Coordination between the parties during construction to ensure the zone is ready to work for a certain party*: From the model with the help of 4D integration, each zone can be analysed whether the zone is ready to work or not for certain parties.
- *Making the models open to the client to receive direct feedback*: In some projects, models are open to the clients. The participants believe that by providing access for the client to the models allows instant feedback from the client and better operation and maintenance.

- *Coordination with FM partner*: This activity involves a regular coordination with the client and FM partner to get the feedback on every item during the construction. The projects were found to produce as-built drawing along with the construction process. In this way, the final model is passed through the clash detections and all sorts of coordinations. The preciseness of the model is enhanced.
- *Articulating behaviour in terms of coordination*: The activities of the various parties are precisely defined to facilitate coordination between them during the project delivery process. If any party is intended to work in a particular zone, it is defined how the coordination between the other disciplines will be made for the particular work. For instance, instead of communicating with other parties the manager which is intended to work in a zone will communicate with the BIM station. A BIM station is a central data management station where the people will examine the zone from the model and check with update information whether the zone is ready for work or not. If any earlier coordination is necessary that will be conducted through the model. Relevant parties will address the issues as annotated in the model. The parties in the projects believe that they can concentrate more on work rather than spending efforts on coordinating between the parties.
- *Model is used as communication channel*: Sometimes, models are used a communication channels with the provision of annotation and notifications through the model. A lot of time is saved in this way.
- *Offsite manufacturing*: Not only in design coordination, value of BIM is added by offsite manufacturing by taking off the elements of a building from the model and manufacture them outside the project site. This includes concrete panel, ducting panels, and piping works. It makes easy to fix the items without being any clashes. Potential clashes are detected and mitigated prior to use the digital information from the model to the manufacturing machine.

Number of value items considered in design and coordination process

Various projects consider different number of items considered during the value proposition of BIM. The activities undertaken in various projects are shown in the table 5-7 below:

Table 5-7: Number of value adding items considered in design and coordination process

No.	Value optimisation activities	Score											
		P01-HW	P02-HA	P03-FA	P04-SS	P05-CC	P06-WS	P07-TH	P08-DM	P09-SA	P10-AI	P11-SF	P12-HC
1	Reducing clashes	1	1	1	1	1	1	1	1	1	1	1	-
2	Assessing progress by real time data transfer to save time and increase accuracy	1	1	0	0	0	0	0	0	0	0	0	-
3	Integration of time line	1	1	0	0	0	1	0	1	1	0	0	-
4	Integration of cost schedule	1	1	0	0	0	1	0	0	1	0	0	-
5	Coordination in a common data environment to reduce time and effort, enable seamless information flow	1	1	1	0	0	1	0	1	1	1	1	-
6	Developing Configuration Management value	1	1	0	0	0	0	0	0	0	0	0	
7	As built drawing through the design coordination process	1	1	0	0	0	0	0	0	1	1	0	-
8	Reviewing construction procedure	1	1	1	0	0	1	1	1	1	1	1	-
9	Coordination between the parties during construction to ensure the zone is ready to work for a certain party	1	1	0	0	0	1	0	0	0	0	0	-
10	Making the models open to the client to receive direct feedback: ensures better operation and maintenance	1	0	0	1	1	1	0	0	0	0	0	-
11	Coordination with FM partner	1	1	0	0	0	0	0	1	1	1	0	-
12	Articulating behaviour in terms of coordination	1	1	1	0	0	1	1	1	1	1	1	-
13	Model is used as communication channel	1	0	0	0	0	0	0	0	0	0	0	-
14	Offsite manufacturing	1	1	0	0	0	0	0	0	0	1	0	-
	Total number of items considered	14	12	4	2	2	8	3	6	8	7	4	-

Table 5-7 shows the scores in the projects in terms of optimising value for the respective projects. As the scores are given on the basis of number of items considered in the project, a higher score represents a higher number of items considered at the planning stage in order to add value in the projects. Three projects of different scores have been discussed to understand how prospective values are set up in various projects and how it is related to the outcomes of BIM in a project.

In the project P05-CC, the implementation of BIM is performed as an experiment basis. The core design process in this project is still lead by 2D drawings. The respondent P05-RZY mentioned, "*This project is like an experiment*". This statement shows that implementation of BIM in this project is done as a test basis and does not involve the core modelling activities. Consequently, both 2D and 3D based design processes are going on in this project. This is supported by further comment of the respondent "*We have the project from AutoCAD, we also have the project make the drawings from Revit*". This statement clearly shows that both systems are running in this project. The operations of both processes obviously incur more time, cost and efforts. This observation shows that with very limited value adding plan (the project score is low as 2) reflects the value level of in the project. The outcomes 'coordination and integration', and 'interactions between the parties' are also at a low level that can be seen from the respective sections in this chapter (see Table 5-13 and Table 5-18).

The score of project P08-DM is 6 in Table 5-7. In this project, during the implementation plan, a number of activities are considered to add value. For instance, reducing clashes between the functional elements, integration of time lining with the 3D model to assess the project precisely and quickly, coordination between the parties within a CDE to reduce time for design coordination, and reviewing the construction procedure by visualization are considered in the project. In this project, the models are regularly shared with the facilities management (FM) partners. A participant in this project P08-RJH mentioned, "*We will do Navisworks and **clash detection** ... we actually have to pass that model to the facilities management. ...but that's fully documentary in Revit and we produce data drop security to produce facility management report*". This statement demonstrates that there are few activities which are planned to do by using the modelling process to add value up to the operation and maintenance phase. However, saving time through **4D time lining or 5D cost schedule is not done in this project effectively**. As such, planning value for few areas in this project is reflected in the medium score of this project, which covers value up to a certain extent.

The score of the project P02-HA is 12 which is close to highest score (i.e. 14) in the table for P01-HW project. In this project, all the items in the P08-DM project along with few additional value adding items such as reviewing progress by using real time data transfer, integration of cost schedule, developing CM value with respect to as-built model. Participants in this project believe that adding value in the project though the implementation of BIM is important. A respondent P02-RDGM commented, "*…you got the design team involves and working in certain way, the model should be used, not the drawings, then you can demonstrate the value* *of the model and the way through, all described in the model*". From this statement, it can be observed that the participants are intended to use model at an optimum level that will contain all the necessary information. The statement further indicates that the value planning in a particular project is related to the inherent value in the model and it should be achieved through the coordination and integration in the project. This is supported by a participant P01-RAF who mentioned, "*We are trying to integrate the model as much as we can, and if we have any coordination issues on site, we generally open up the BIM model, so that our peers can communicate around the BIM model itself*". The first part of the statement describes that the people in the project are trying to integrate the model as much as they can to save time, cost and effort. The second part of the statement reflects the goals in terms of coordination and integration which can be achieved through optimising value. Also, it can be seen from the statement that **parties perform coordination and integration and interact between each other on this project**. Other value creating items are also considered in this project; for example, zone based coordination to ensure safety and workability in a particular zone, and offsite manufacturing. Hence, more items are considered which can add value in the project than what is already done in a project with medium score in these two projects, and the project scores are higher.

Based on the above discussions on three projects, it indicates that value optimisation is related and influential to the categories 'coordination and integration', 'value level of BIM' and 'interactions between the parties' in a BIM project.

5.2.4 Data Exchanges and Accessibilities in BIM Projects

Data accessibility has been found as a contractual right of individual contract parties in a BIM project. The delegated persons maintain the central data repository and update it regularly through the server. Individual projects use various systems of exchanging and accessing data. In various projects, the nature of data exchanges and accessibilities were seen as different. The properties and dimensions of the category "Data Exchanges and Accessibilities" have been articulated to observe the various ways of information management and possible relationships with the other categories. The properties and dimensions of this category are shown in Table 5-8.

Table 5-8: Theoretical sampling of "Data exchanges and accessibilities"

Data exchanges and accessibilities (Catgeory-04)	
Properties	Dimensions
Various types of software used in the projects Information management and flow	Level of integration in data management (level of data availability and access, and level of collaboration and integration in CDE)

Various types of software used in the projects

The process of the implementation of BIM in a construction project is underpinned by technology which involves numerous software packages to serve various purposes within the supply chain. For instance, a particular software is used to produce 3D information models, whereas another one is used to structure the construction programme. If these two entities need to be integrated, another software is required to plug-in them. Eventually, one can view the progress with time line of the project by clicking a particular item in the timeline to see the relevant item in the 3D model separately.

Information management and flow

Multifunctional parties have open access to the data in the projects via different servers. In a BIM project environment, participants feel that there is no necessity to hide any information, and it also breaches the agreement. Even the client can see the information and monitor what the whole construction team or individual party is doing and how they are spending the resources. When someone enters into the repository, the person can see the same information as anyone else can see at the same time. In a particular situation, data accessibility also allows the participants to understand better regarding the area of work if it is free to work safely or not. This is performed by recognising the certain items such as number of people working on that place, the part of the work is completed already, the existing schedule of the work upfront to carry out individual works, and the interdependent work packages.

Level of data availability and access

The level of availability and access to the information for various functional parties in a project means the extent of availability and the nature of available data in the common data environment (CDE). According to the available feature in various projects, data in a BIM project can be made available and accessed by following ways:

- *Available as individual live models*: Individual models are uploaded by relevant parties and uploaded. In an individual live model people can add annotations and comments. In this way, model based interactions between the parties are enabled.
- *Available as individual models*: Individual models are available which can be downloaded and used by different parties for various purposes such as reference or clash detections.
- *Available as single frozen model*: A single frozen model is the integrated model which can only be viewed by the participants to enhance understanding on the completed state of the work for a particular item.
- *Available as integrated live single model*: Sometimes integrated model is also available as live model where people provide annotation and additional information at a regular basis.
- *Regular update*: Regular update is a part of terms in the BIM implementation plan. Parties produce information and upload once the information is passed through the examination process.
- *Individual open access and download file*: Individual parties have access to certain data to carry out their own works.
- *Individual file upload in the central repository*: Uploading data into the central repository is limited to certain parties. The capabilities of the parties are examined whether they can produce meaningful information in a certain format.
- *Client access*: In particular cases accessibility is enabled for the client to view the progress and other necessary things. For example, in the project P01-HW project, the client has access to the 5D cost information, so that the client can view how much money has been spent till a certain date.

Level of collaboration and integration within CDE

Collaboration and integration within the CDE take place through various activities. Following activities have been found taking place across the projects:

- *Changes follow notifications through the model*: When there is any changes in the model, the information is passed through the model to the relevant parties. Notifications are also included in the model by which parties can easily understand the issues.
- *Documents controlled through the server*: Gathering data and organising the data are often done through the server in the BIM-enabled project.
- *All data flows through server*: In some cases all the documents pass through the server. Exchanging any piece of information must be done though the server.
- *Agreed and implemented data exchange system in the project*: Effective data exchange and management system are functionalised when the agreed protocol is fulfilled by the participants.

It was asked to the participants that how to deal with the situation if some people wants to control their information and not willing to disclose sufficiently to keep their business consistency. Some of the participants mention that such an attitude will not work in BIM environment. BIM ensures the availability of data on time in a central repository. A relevant comment from a respondent was, "*Most of these are web based that are utilised to comment on drawings, raise queries, regard approvals, so, that's main we are doing*". This shows that parties carry out several activities through the data exchange system in the project. This also demonstrates that the central data management system is the core attention of information within the project.

The above described elements appeared as dominating factors for the "Level of availability and access" and "Level of collaboration and integration within CDE" in various projects. These two parts are merged as 'Level of integration in data management' to render the dimension of the category 'Data exchanges and accessibilities in BIM projects'. The presence of these elements which render the dimension of the category in various projects are listed in Table 5-9:

Table 5-9: Level of integration in data management

No.	Items	Projects											
		P01-HW	P02-HA	P03-FA	P04-SS	P05-CC	P06-WS	P07-TH	P08-DM	P09-SA	P10-AI	P11-SF	P12-HC
	Level of availability and access												
1	Available as individual live models: Annotations	1	1	0	0	0	1	0	1	1	0	0	-
2	Available as individual models	1	1	1	1	0	0	1	1	1	1	1	-
3	Available as single frozen model	1	1	0	0	0	0	0	0	0	1	1	-
4	Available as integrated live single model	1	1	0	0	0	0	0	0	0	1	0	-
5	Regular update	1	1	1	0	0	1	1	1	1	1	1	-
6	Individual open access and download file	1	1	1	1	1	1	0	1	1	1	1	-
7	Individual file upload in the central repository	1	1	1	1	0	1	0	0	1	1	1	-
8	Client access	1	1	0	0	1	0	0	0	0	0	0	-
	No. of elements present	**8**	**8**	**4**	**3**	**2**	**4**	**2**	**4**	**5**	**6**	**6**	**-**
	Level of collaboration and integration within CDE												
1	Changes follow notifications through the model	1	1	0	0	0	0	0	0	0	0	0	-
2	Documents controlled through the server	1	1	0	0	0	1	0	0	0	0	0	-
3	All data flows through server	1	1	0	0	0	1	0	0	1	1	0	-
4	Agreed and implemented data exchange system in the project	1	1	0	0	0	0	0	1	0	1	1	-
	No. of elements present	**4**	**4**	**0**	**0**	**0**	**2**	**-**	**1**	**1**	**2**	**1**	**-**
	Total Score	**12**	**12**	**4**	**3**	**2**	**4**	**2**	**4**	**6**	**8**	**7**	**-**

In Table 5-9, although the scores are calculated together, the elements of the category is divided into two parts to understand what is meant by the category and how it works in the project while operating BIM in terms of data exchanges and accessibilities. A higher level of data exchange should have higher number of elements present in the table and have facilitate the participants to gain benefits from the BIM-enabled system of data exchanges and accessibilities. Following discussions have been made on three projects of different score ranges to understand the nature and impact of various levels of data exchanges and accessibilities to the outcomes of individual projects:

According to the information provided in Table 5-9, projects P01-HW and P02-HA have a highest score of 12 each. In project P01-HW, the models are available in various modes for different purposes. For instance, when the models are available as live, people can put annotations and annotations are passed to the relevant parties through notifications. Individual models are available for the other parties to use them for interactions or integration purposes. Integrated single model is also available in this project in two modes i.e. **both frozen and live**. **An integrated live model is open to insert annotations** and thoughts from the relevant parties whereas a frozen model is used to look on the integrated model how the project should look like on a particular date. The frozen model is updated regularly and the **changes are followed through notifications**. In this way, a rigorous and active data exchanges and accessibilities can enable better collaboration and remove process fragmentation in the project. It also can have impact in the ultimate as built model for the operation and maintenance phase. A participant P01-RAF mentioned, "…*every week our document control are just asked to press the button and update any changes that are been made to all of our subcontractors' models. So, within that main model you will have your CM value…we also have separate entity models, can separately be saved and then within the middle of that*". This statement demonstrates that the existing system of data exchanges and accessibilities facilitates the participants to view the latest information including the changes made, at any time they need. At the same time, **the system contains the as built model** which can be viewed by the client to receive any instant feedback, which saves time and builds trust and relationship between them. This is supported by the respondent P01-RPH, he mentioned, "*There is completely open access and that is completely open book. So our client sees what we are spending. We don't need to hide anything, and we have a good relationship with our client*". This illustrates that **individuals have open access and can upload or download the model for their own purpose**. Also, the client has access to the cost schedule integrated models as well which enable a higher level of accessibility and integration of information within CDE. The data management process is implemented as agreed, in this project.

The above discussions indicates that with an ultimate level of availability and frequent accessibility of information, the participants of this project can save time on collecting and passing information, which encourages collaboration between them. Additionally, they gain a higher level of trust between each other and with the client as well. More coordinations and interactions also take place with a better system of information management. Hence, this observation describes the feature of the project P01-HW behind a higher score in the table 5-9.

In project P11-SF, the score is 7. In this project, models are available as individual and a single frozen model which is updated regularly and people have access and get some advantages from it. The participant P11-RSM mentioned, "*Actually between us we just exchange through the server….in our office we have one model where everyone can access. We have one file for trade and we link this file with the trader to create one common model. We print views from this model for the people who cannot have directly see from the model can see views from the models.* This shows that there is a data exchanges and accessibilities system in place, functionalised, and people are advantaged but some of people do not access who need to see the printed views of design information. Additionally the system has limited functionality. The participant further stated, "*No, there is no such kind of notification system in the models*". This says that the advantage of notification and communication provision that could be enabled by the system in the same way which is enabled in the project P01-HW. From this observation and this statement, as a whole in brief, in this project the data availability and accessibility is at a considerable level, people still get benefits in terms of gathering and managing information but not at extensive level. Hence, this project has an upper medium level of score.

Most of the people involved in design process in P03-FA project reside in the same office to enable better communication and coordination for this project. As the people sitting in the same office, there is less necessity felt by the people in terms of **data availability and accessibility through a common server** in this project, this may discourage them to collaborate though the modelling process. However, this project has a CDE as general criteria of the leading organisation. Individuals have access to the CDE and all the information are passed through that whereas controlling data is not a significant through the server in this project. This means, people can also gather information from silos. A lot of activities are planned to do in this project but not implemented as it should. Consequently, less collaboration and integration take place among the participants within CDE. This is supported by the participant P03-RNW, and he asserted, "*The modelling and information model point of view which hasn't set yet*". This shows that a truly data exchanges and accessibilities system is still not fully functionalised. This consequence and reason is reinforced by the participant in the project; he added, "*They haven't realised that holistic cover that goes into their operational requirements, for the business that goes match into the client's operational requirements on the supply chain…. is got to* *understand that asset information requirement the long-term holistic whole lifecycle value getting the most of that information you need to consider. And, they don't realise that construction site requirements also need to be considered. And that needs to be considered before we start. So, they don't have to redesign* or *re-plan. …they don't realise there is competition. Because, if they do realise that, of doing more education in 3D for application it into a systematic coordination approach. And that's the current situation*". This statement shows the weaker capabilities of the existing information management system. Further, a tone of disappointment in terms of difficulties in implementing the agreed plan can be seen here. From the observation and the statements it can be seen that data is not frequently distributed among the participants of various phases in the project and the collaboration within the information management is not duly functionalised. Also, frequent interactions between the parties hindered. Consequently, all parties are not getting advantages as well as the model does not cover the whole lifecycle of the project. Hence, the project has a lower level functions and impacts of data exchange and accessibilities; and the score is low as 4.

From the above observations in the projects, it can be seen that there are different feature and stories existing behind the score of each individual project. This can be argued that a higher score in table means the higher level of coordinations and integration and frequent interactions between the parties within the respective projects, which is facilitated through the data exchange and accessibilities. A medium score in a project represents a good level of achievements in terms of outcomes in the projects but not at the extensive level as a higher scored project. From the projects discussed above, there is a tendency of improving the process and adding value in the project. For instance, in project P01-HW it has been found that feedback from the operational body in the as-built drawing helps to improve the model for the ultimate owner of the project to use for their operation phase, which in turn adds value in the project.

5.2.5 Capacity Building Programme in BIM Projects

In this study, it was observed that that all the parties involved in a construction project are not up to date and capable of affording leading-edge technology such as BIM. In order to minimise the differences in skills in terms of desired deliverables in the projects, managements in various projects undertake a number of capacity building programmes according to the necessity of the particular projects. It was observed that capacity building programme varies from project to project. It was quite ambiguous whether there is any relationship exists between the capacity building programme and the success of the implementation of BIM. To examine the existence of relationship, the following theoretical sampling of “Capacity building programme in a BIM project” was established which is shown in Table 5-10 below:

Table 5-10: Theoretical sampling of “Capacity building programme in a BIM project”

Capacity building in a BIM project (Catgeory-09)	
Properties	Dimension(s)
Diverse capacity building programmes	Number of capacity building activities Extent of reusing the knowledge from learning

Diverse capacity building programmes

Various capacity building programmes have been found in various projects. Particularly, two areas subcategories have been identified in the capacity building programmes across these projects. These are: 1) diverse capacity building activities are undertaken in BIM projects, and 2) knowledge is reused in the projects from the learning activities. Various capacity building activities that have been found undertaken in the investigated projects are as follows:

Special learning programme for improving coordination and integration: This learning programme is a type of workshops to ensure that the participants in the particular projects understand the level and type of coordination are to be performed in particular projects. For example, the way of uploading or downloading information and model interactions are discussed in this type of learning programmes.

Learning programme for various software: Participants are assessed to determine the level of existing skills among the various functional disciplines. Necessary training course are arranged to enhance the level of skills which will ensure the deliverables in the particular projects.

External programmes for the participants: In some cases, participants are sent to outside organisations to attend external learning sessions. Trainee graduates are the most frequent participants of this kind of learning activity.

Special brainstorming session: Brainstorming sessions are arranged where recent and upcoming critical problems are discussed to make sure that similar problem will not occur in future.

Target set up to enhance capacity to a desired level: Targets are set up for individual parties to enhance desired level of skills to articulate the capacity building programmes for individual parties.

Shadow learning programme: If any party in the project has a lack of desired skills but cannot attend the capacity building programmes, certain part of the job of that party is delegated to another party and the incapable party is shadowed with the other party within the project with special financial arrangements. In this case, the incapable party can learn from the other party by working together.

Video learning programme: There are some learning programmes based on video training where participants can learn necessary skills to be applicable in the projects.

Project forum to discuss coordination: In some projects, there are project forums to discuss the coordination manner in terms of sharing data and knowledge to coordinate.

Deployed BIM coordinator to improve capacity: This is a very common capacity building approach across the projects inside the UK. A BIM coordinator supports the people in the projects frequently to ease the difficulties in producing and coordinating the information.

There are number of ways through which people reuse knowledge within the ongoing projects. However, these are not found frequently found across the projects. The various ways of reusing knowledge are sated below:

*Reflection of learning in the next phas*e: Reflection of learning by the trainee graduates in a project can apply the knowledge in the next phase of the same project.

Formal progress review for capacity building and bring the learning into practice: The progress review of the learning activities are reviewed whether gained knowledge can be used or shared within the project or not.

Visible learning curve and results: Learning by doing enables visible learning curve within the projects. Once people carry out any BIM activity for the first time with few difficulties, those activities can be carried out in the next phase without any difficulties.

Sharing knowledge through learning by doing: When people do something with the help of training, shadow learning programme, or any other activities, knowledge sharing is enabled among the participants.

Reuse knowledge from leadership learning: When a project leader undergoes in learning activities in terms of BIM whether formal or informal, such kind of knowledge is used within the project immediately.

Number of capacity building activities and extent of reusing the knowledge

Various projects have different levels in terms of number of capacity building activities and extent of reusing the knowledge. Following Table 5-11 shows the variation in these two dimensions across the projects:

Table 5-11: Capacity building programmes in various projects

No.	Capacity building programme	Projects											
		P01-HW	P02-HA	P03-FA	P04-SS	P05-CC	P06-WS	P07-TH	P08-DM	P09-SA	P10-AI	P11-SF	P12-HC
	Number of capacity building activities												
1	Special learning programme for improving coordination and integration	1	1	0	1	0	0	0	0	1	0	0	-
2	Learning programme for various software	1	1	1	0	1	1	0	1	1	0	0	-
3	External programmes to attend for the participants	1	0	0	0	0	0	0	0	1	0	0	-
4	Special brainstorming session	1	0	0	0	0	1	0	1	0	0	0	-
5	Target set up to enhance capacity to a desired level	1	1	0	1	0	0	0	0	1	0	0	-
6	Shadow learning programme	1	0	0	0	0	0	0	0	0	1	1	-
7	Video learning programme	0	1	0	0	0	0	0	1	0	0	0	-
8	Project forum to discuss coordination	0	1	1	0	1	0	0	1	0	0	0	
9	Deployed BIM coordinator to improve capacity	1	1	1	1	0	1	1	1	1	0	0	-
	Score	**7**	**6**	**3**	**3**	**2**	**3**	**1**	**5**	**5**	**1**	**1**	**-**
	Extent of reusing the knowledge from learning												-
1	Reflection of learning in the next phase	1	0	0	0	0	0	0	0		0	0	-
2	Formal progress review for capacity building and bring the learning into practice	1	0	0	1	0	0	0	0	1	0	0	-
3	Visible learning curve and results	1	1	0	1	0	0	0	0	0	0	0	-
4	Sharing knowledge through learning by doing	1	1	0	0	0	1	0	0	0	0	0	-
5	Reuse knowledge from leadership learning	0	0	1	0	0	0	0	0	0	0	0	-
	Score	**4**	**2**	**1**	**2**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**-**
	Total Score	**11**	**8**	**4**	**5**	**2**	**4**	**1**	**5**	**6**	**1**	**1**	

Different projects receive different scores for its capacity building programs (see Table 5-11). Scores for three different projects are discussed here to improve the understanding of feature and impact of the capacity building programme in the projects. A higher score means that there is sufficient capacity building activities in practice in the particular project to enhance technical and data coordination capability for the relevant people within the project.

For P01-HW project, the score is 11. In this project, there is intensive learning programme from the lead organisation for the people from different companies to learn about the implementation of BIM through their people working in the project. As there are numerous new software packages and process being used within the project delivery process as an integral part, the new comers require learning to use particular software packages packages. The participants in this project are encouraged to join and learn the necessary software packages along with the main contractor's learning programme. A respondent P01-RAF asserted, "*We are trying to allow them to come in, so we are trying to spread the word a bit because if we learn now how to do it this the trying to get them to learn along with us. Because you will get to in a point in few-year-time where everyone like management level is quite happy using Navisworks and then you give it somebody on site can right go and solve the issue then you go look at it*". This statement demonstrates that **the parties involved in the project is supported by the management** body of the project to build their capacity to a certain level so that the problems are solved though the model, **collaboration and integration are improved** and the deliverables are ensured with holistic cover. A higher level of coordination and integration takes place in this way. Also, this is important to be mentioned that there is a learning curve which exits within the process to improve the whole project delivery process for the project running as well as future. Therefore, from the discussion, it is seen that there is a wide and intensive **capacity building programme** in this project which covers all the relevant participants and various areas of learning in the implementation of BIM. Reuse of knowledge is very much focused in this project. Hence, the score in this project is high. This is also visible in the project that the project leader is keen in capacity building in this projects and he takes important role and designs in the capacity building programme in this project. This indicates that capacity building programmes in the BIM projects may be linked directly with leadership within various projects.

In P08-DM project, the score is 5 for the capacity building programme existing within the project. In this project, there is a project forum for discussing the BIM related coordination activities and a BIM coordinator is deployed to support. A BIM manager is deployed to teach the participants necessary software to be used in the project. The BIM manager P08-RJH described, "*I am also teaching staff, how to use Revit, this is actually a first Revit project in Glasgow*". This shows that **the learning programme is focused on the deliverables in hand**, not for the longer future. There is no wider scale capacity building programme undertaken in this project, say, for example for the graduates or covering whole supply chain. The BIM manager in this project shares knowledge with the project leader frequently and the learning has a reflection in the project. There are few capacity building activities in this project and hence the score is at a medium level.

There are capacity building programmes such as training for the other parties in the project P05-CC. As the lead contractor is an experienced organisation in terms of BIM, the organisation try to provide necessary support for the contract parties to enhance skills. There is a project forum to discuss important issues. It can be seen in the project that the information share in between the parties do not take place as a truly BIM process. There are limited capacity building activities in this project, and hence the score is very low as 2.

From the above observations in various projects on capacity building programmes, it has been established that respective scores of individual projects reflect the state of the capacity building activities which also link other activities such as participating in coordination and integration activities within various projects. It is also observed that the project leader has relevance with the capacity building programme in the respective projects.

5.2.6 Coordination and Integration in BIM Projects

Coordination and integration in BIM projects were found quite visibly dynamic across the projects. There is a strong involvement of intelligent model and the on-going works in the projects. Particularly, in P01-HW, P02-HA, P09-SA, and P10-AI projects it has been mentioned by the participants that the planning team always tries to integrate the model at the optimum level which relates the physical construction works driven by individual functional parties. In a BIM project, when an issue is raised, the model is opened up and related parties look into the model about the issues and find out the way to solve the issues with visualizing the consequence of the proposed solution. Sometimes, people also communicate through the model. Most of the projects have been found to use server to exchange and manage data. To observe the coordination and integration activities taking place in various projects, the theoretical sampling was done for this category. Table 5-12 shows the theoretical sampling of “Coordination and integration in a BIM project”.

Table 5-12: Theoretical sampling of “Coordination and integration in a BIM project”

Coordination and Integration in a BIM project (Catgeory-17)	
Properties	Dimension(s)
Design coordination The gradual process of integration Integration of technology and process Types of coordination	Level of coordination and integration

Design coordination

To functionalise the interactive design coordination including construction and handing over the project, it is necessary to produce sufficient information. It has been found that there is a difference in working procedures between the parties in terms of producing information and coordination for modellisation. The information produced by the parties are put into the model which is termed as modellisation. A model must be (exported, if requires) cross checked by modellisation prior to send the relevant part to the other parties or process such as offsite manufacturing.

For the equipment relevant to different parties, it is put in the model along with all the amenities, accessories and building elements before manufacturing any part of the building. A complete set of 3D and digital information of the particular part of the building is required to be in place and necessary tests are conducted. After testing and commissioning via model, the information are uploaded and made available to all the parties.

In particular cases, the consultants are not based on site but they have regular visits on site. The people are using central data repository and working in a common platform. A number of participants mention that it is difficult to build mutual trust and openness between the parties when they are not sitting in one building. However, if there is an issue that is pre-suggested by the contract to resolve by the process. Parties step forward, and the process BIM works as the driving force to work together. Various functional parties exchange their documents as per guidelines mentioned in the contract. As the whole process is demonstrated earlier, it makes easier for the parties to integrate with the process of BIM.

Sometimes, a particular discipline takes lead role to coordinate with the relevant parties. For example, fire alarm installation people coordinate with rescue discipline and other parties such as M&E to figure out the relevance, operational convenience and effectives of the system. Integration between the parties takes place among diverse groups of the people within the project team. However, in the most cases, people concentrate on what is written in the contract and mentioned in the drawing. It is necessary to mention the desired behaviour between the parties in the contract; it was mentioned by a respondent.

The gradual process of integration

It has been found that there are several activities undertaken in a BIM project to make all the parties to be understood that they are working as a team. A true collaboration is functionalised through coordination and integration when the objectives of all the parties are focused towards single product for which all of them are gathered. The participants in the whole project team work in a single stream of modelling process within the project. The work stream is steered through the modelling process. For instance, any major change such as reducing the time length of a project also changes the level of coordination in a project, speed of teamwork by pushing all the parties to meet the new deadline.

Different functional parties coordinate about several entities of particular packages. With the help of visualisation, it becomes clearer about the number of parties in presence for the particular item and the sources of various issues. For example, in P01-HW project, in a small area, when a number of parties come to coordinate with other related people with the details like the number and type of technicians are working on that location for which days of the week, what the physical condition of the works are at the particular location. All these information are recorded in the model and published weekly or fortnightly are set up on the day-1 meeting.

There are also different strategies of coordination and integration exist in the projects. For example, in project P01-HW, one of the major intentions of the planning and implementation team is to provide support and information to carry out the work with required workforce by maintaining highest safety factor. In that case, working in a single area is managed in a certain way where the minimum number of parties will work at a time at that point. The belief that works among the people is working with more people in a single point increases the level of risk. People step into the BIM station to get the information about who are entering into the area to work on which day, and what arrangements and equipment is supposed to be there, how the working point is looked like—all these information are recoded in the model, updated regularly, and are delivered to the concerned parties for the particular time period.

Implementation strategy and plan is undertaken in the few projects has been found as transparent and affordable to undergo desired coordination process. It has been seen that a project specific implementation strategy and plan encourages people to work together and finish their own works within the time frame. For instance, in order to understand the value and the process of BIM, regular meetings are held in various projects. The key focus of the meetings is on collaboration and teamwork, which has been confirmed by a number of respondents. Most of the collaboration and coordinations take place among the consultants through the regular meetings. In some projects, if there is any conflict between the parties there are referees in place to resolve the conflict. Previous level of integration is continued once the issue is resolved.

It is found in the investigated projects that integration happens between the parties gradually and it is cultured within an organisation gradually along the learning curve. It has been agreed by a number of respondents that at first, smaller projects are to be completed with BIM and then get on board with a large project. In this way, the learning curve becomes steep along with the progress of the large projects. As mentioned by a participant P02-RGC, BIM is becoming the central media of coordination and discussion within the projects day by day and the companies are getting with other companies of similar culture in terms of BIM and step forward. Particularly, in projects P01-HW and P02-HA, to satisfy client’s requirement, BIM has to be used at its ultimate effective level. For example, in these projects, manufacturing the concrete panels comes from the strategy of the main contractor and the client’s requirements, and the design consultant organisation moves along with them. Evidently, it is a different kind of integration that is coming through the implementation of BIM. A respondent (P02-RGC) commented, "*So, we really are taking BIM taking on kind of boards and group discussions. (The leading company)… is in a similar kind of sort of positions is more to report to them to send external it is really good through BIM because they build buildings of manufacturing concrete panelling system. They can make only sort of fast programmes; they have to meet the client's aspirations by really using BIM to its ultimate. So, our BIM model goes to the production factory sort of concrete panels now at the site. The factory in workshop is kind of 'James Bond' they set. So it is fantastic process*". According to this statement, it is clear that the volume of producing digital information and reporting to the main contractor is more in a BIM projects than a typical project, and the consultant is moving with the main contractor. It is also mentioned that the consultant is satisfied with the overall way of work of the main contractor. A gradual cultural congruency has been taken place in this project.

In particular projects it has been found that there is a panel of project forum within the lead organisations for coordination and integration of information with respect to BIM. The necessity and pathway of coming into the common format is discussed in the forum. Prospective consultants and subcontractors within the supply chain are demonstrated about the standards of the company and working culture including the modelling process and using the information system. For instance, sometimes, various parties come in and fly around the site to enable real time data transfer. It is a vital change in terms of participating and integrating with the new working environment. BIM has the potential for this kind of integration between the parties.

In project P01-HW, it has been claimed by the respondents that the working environment in the project is very healthy and the relationship between the contract parties is like a friendship. A manager from a subcontractor P01-RKT mentioned, "*They are working for the same company and work for the same organisation and the money at the end is going to the same pot*". This statement reveals that the whole project is treated as a big group. There are some disagreements between the parties but at the end the decisions are made for the best interest of the project. So, apart from company's own culture and interest, the project interest comes first at some critical moments. This kind of phenomenon happens in the decision making meetings and regular model based pre-set up meetings.

The project team reviews the model on a regular basis where the issues are highlighted with the gradual development of the model by incorporating contributions from all the parties. A project leader mentioned that the current status of the construction industry as 'digital time'. It is also described that the whole project delivery process is fascinating when people do not get around the table but exchange their information through the model. People also solve the problems though the model for certain issues. However, for some issues people are seen to get around the table to resolve them. Sometimes, the lead architect has to see the engineers just like '*jump on the car, go around the engineer, and sort that ou*t'. A direct interaction between the parties takes place in this case.

Integration of technology and process

People working in a single data repository are mainly team focused. As all of them are coordinating between them by considering the intelligent model at the middle, teamwork is embraced by the process of BIM. All the parties focus on the common goal and the deadline they are intended to meet.

Time lining and cost schedule are integrated to the model (4D or 5D). People can visualise the day to day updated physical progress with all sorts of dimensions provided in the model. For instance, if the financial programming is plugged into the model, it is possible to see the financial progress along with the physical progress. One of the most effective activities of BIM is that people can visualise the issue which fosters the process to identify the problems and to draw the solutions. There is no place for ambiguity in this process. Decision making becomes quite easier, as mentioned by the participants.

In few BIM-enabled projects, participants have been found personally interactive. The people feel encouraged to come into the project and discuss the issue and go through the model to solve it. There are regular meetings between the parties and regular exchange of information to upload to the server. As agreed by the participants during the implementation plan, parties coordinate between them to accomplish any work package. For instance, for manufacturing concrete panels in the factory, architect, engineers and M&E people are coordinated prior to send the information to the cording machine of the manufacturing plant. An advanced kind of requirements for the manufacturing is met by the various parties.

'There is a great deal of integration in BIM-enabled projects', a respondent mentioned. Floating time is also left for the parties to discuss between each other and arrange their own settings for particular work. If a project is too large to coordinate and integrate, it is broken into parts to enable effective integration between people, process and technology. People can then easily follow the construction sequence along with the live model.

Integrated data management

In some projects, a separate data management body and infrastructures for operating BIM have been found. Particularly in P01-HW and P02-HA projects, the document control station used in the project is called BIM Station which deals with the central data repository and management of information. This is a vital part of the project delivery process of the lead organisation. This data repository holds everything together including the models. The main model which remains frozen for a specified time period is updated regularly with a single press on the button. In the main model CM (configuration-management) value of the main contractor is incorporated, similarly the individual models contain the CM values configured the respective companies. The clients access into the model and provide necessary feedback if there is any particular requirement on the CM value of the intelligent model to be used by the facilities management.

In a number of projects, it has been seen that there is a single model available in the data repository along with the individual entity models. These models are updated regularly. If there a change is made, it is made clear to the people about the possible changes in their works and necessary actions. Prior to upload any information it is passed to the relevant persons to review. After the review and necessary editing tasks it is uploaded to the central data repository. People get the latest information from a single source.

In a BIM-enabled project, wherever the parties reside, the connectivity with the model makes them open minded to discuss any design coordination issue between the consultants. For instance, it has been claimed by a participant P02-RGC that in the 3D world, there is no chance of keeping away the information for business interest. Design consultants reside virtually closer. Number of respondents has mentioned that the frequency of interaction between the parties increases and the process fragmentations are minimised. It has also been asserted that the people share information and idea in between them frequently which enable them to develop an effective teamwork.

Projects are often seen using distinctive information management systems. For instance, in P08-DM project, there is a Revit Cluster server which is maintained by the BIM coordinator from London. This server is accessed by the relevant people across the UK. To maintain and update the information in the server, frequent communications occur between the parties internally, as mentioned by a respondent. The communication channel is open to the people. People working from different silos feed their information and relevant people are informed via email or telephone. Discussions are made among the consultants via email, over telephone and face to face. For example, there is a fortnightly design coordination meeting between the parties in project P08-DM. The number of documents required produce and exchange between the parties within a specific time period are discussed and agreed by the relevant parties. Such kind of agreement is strictly followed.

In a BIM-enabled project, when a problem occurs, the relevant parties are called immediately to discuss the problem. If it is required, workshops are held for particular problems to avoid the similar occurrences in future. For example, in P08-DM project, there is an hour and half meeting in every week where pragmatic issues are discussed. A higher level of collaboration takes place in this way, as claimed by a number of respondents. In this kind of weekly meeting, models are opened and issues are discussed with relevant visualisation. There is a learning curve existing throughout the project delivery process and new skills are gained from such interactive activities.

In a project with BIM in operation, data is collected by the architects and the designers and passed down to the construction engineers; and finally then, from the construction engineers to the FM. During these exchanges, a lack of mutual trust often exists between the parties. It has been claimed by a number of respondents that when BIM is on board and data is uploaded into a central repository, such kind of lack of mutual trust is removed.

Types of coordination

In a BIM project, especially in a higher value oriented one, most of the coordinations are underpinned by the information model. However, people also coordinate and interact between each other via typical modes such as face to face meetings, telephone, and emails. In general, following two types of integrations found across the projects:

a) *Model driven coordination and integration*: The activities and elements of this kind of coordination is basically model oriented. Central data repository and management system are the key elements to functionalise this kind of coordination.
b) *Non-model driven coordination*: This kind of coordination is done through the typical process such as telephone conversations, exchanging information during face to face meeting, and via emails.

Level of coordination and integration

The level of coordination and integration in BIM projects have been found as a consequence of the implementation of BIM. When BIM is operated in a project, parties coordinate and integrate between themselves through various activities and processes. There are several elements and activities found in the projects in terms of coordination and integration which appeared as the representing elements of the level of coordination and integration in the various projects. The names of the activities and presence of those in different projects have been listed in Table 5-13 below:

Table 5-13: Level of coordination and integration in various projects

No.	Elements of coordination and integration in the projects	Projects											
		P01-HW	P02-HA	P03-FA	P04-SS	P05-CC	P06-WS	P07-TH	P08-DM	P09-SA	P10-AI	P11-SF	P12-HC
	Model driven												
1	BIM station for functionalising coordination	1	1	0	0	0	1	0	0	0	0	0	
2	Using common platform	1	1	1	0	0	0	0	0	1	1	1	
3	Federated model	1	1	1	0	0	0	0	1	1	1	0	
4	Coordination through the annotations and notifications	1	1	0	0	0	1	0	1	0	1	1	
5	Model interactions	1	1	1	1	1	1	1	1	1	1	1	
6	Communication through the model	1	0	0	0	0	0	0	1	0	0	1	
7	Integration of time line in the model	1	1	0	0	0	1	0	0	1	0	0	
8	Integration of cost in the model	1	1	0	0	0	1	0	0	1	0	0	
9	Update or changes are coordinated through the server	1	1	1	0	0	1	0	1	0	0	0	
10	Review the progress from the integrated model	1	1	0	0	0	0	0	0	0	1	0	
11	Coordination within particular zone to work	1	1	0	0	0	1	0	0	0	0	0	
12	Coordination within full construction area	1	1	1	1	0	1	1	1	1	1	1	
13	Coordination with client through the model	1	0	0	0	0	1	0	0	0	0	0	
14	Fully functionalised offsite coordination	1	1	0	0	0	1	0	1	0	0	0	
15	File exchange and distribution through the server	1	1	1	0	1	1	1	1	1	1	1	
16	Offsite meeting through computer screen share	0	0	0	0	0	1	0	0	0	0	0	
17	Coordination within different time zones	1	0	0	0	0	1	0	0	1	0	0	
18	Coordination and integration driven by technology	1	1	0	0	0	1	0	1	0	0	1	
	Non-model driven												
19	Face to face meeting	1	1	1	1	1	1	1	1	1	1	1	
20	Email	1	1	1	1	1	1	1	1	1	1	1	
21	Telephone conference or video call	1	1	1	1	1	1	1	1	1	1	1	
	Total Score	**20**	**17**	**9**	**5**	**5**	**17**	**6**	**12**	**11**	**10**	**10**	

In Table 5-13, it is observed that in various projects, the scores are different. The overall feature of coordination and integration across the projects shows that there are various levels of coordination and integration taking place in the projects.

The higher or lower score in the table represents how the coordination and integration take place in a particular projects and cause impact at different level. The desired higher level of coordination and integration should meet the maximum number of points mentioned in the table and everybody should be participated in the modelling process. For example, projects P01-HW and projects P02-HA have higher levels of coordination and integration and have scores 20 and 17 respectively. In P02-HA project, with establishment of **a separate BIM station for coordination**, this project has number of activities reinforced by the implementation of BIM such as working in **a common platform** with **federated model**, **fully server based information exchange system**, **4D time lining and 5D cost integration**, and **clash detection**. In this project, a respondent P02-RDS described, "*So all that works done before hand to the structural and MEP services don't clash…we can add then time element on it 4D with our planners… we can show to the operational team how the building comes together in a sequence and explain to the guys on the site via the visual method of statement"*. This shows that individual models are coordinated, integrated, and interacted, and **potential clashes are detected** prior to commence the work. **Progress review and cost review** are also performed through the integrations of programme and cost. Besides, the virtual construction method and product enables better **understanding on the building procedure** and operation phase of the project. Such kinds of activities ultimately build clarity and understanding among the participants within the supply chain as well as enable better coordination and integration among them. The ultimate consequence of this feature of collaboration is achieving goals through an integrated project delivery process. This is supported by a participant P02-RAR, and he said, "*…we mentioned earlier with our objectives in terms of what we are to the end and buy-in and embed-in people from different objectives within everybody's appraisal system means that they are now on the way to do that*". This shows that despite having different organisational objectives people are truly embedded with the integrated delivery process of the project. At the same time, this statement also indicates that articulating the BIM implantation plan is important to enable better coordination and integration. Hence, coordination and integration are important; and a higher score of a project in the table means that in the project, integration of people, process and technology will take place to have a smooth journey through the project delivery process towards the common goal by minimising the cultural diversity between the parties. In this discussion, this feature is seen in P02-HA project, and the score is higher.

Picture of coordination and integration is different in project P05-CC than that has been seen in project P02-HA, and the score 4 in this project is comparatively poor. In this project, in terms of application of BIM, the only technical integration and coordination related performed activity is clash detection by model interactions. There is an in-house file exchange system where the parties exchange files. These limited activities in terms of coordination and integration inhibit the project team to extract benefit from BIM. The project uses both CAD and Revit, participants do not avail the advantage of working in a common platform or federated model. The respondent P05-RZY added, "*We have the project from AutoCAD, we also have the project make the drawings from Revit, both*". This shows that the project is executed through the traditional 2D drawing system, and producing 3D model is an extra work rather than **reducing potential hazards** in the project or effort of time spent in coordination. Though they have model and server, all the parties do not have frequent access to the server, and the **coordination through the model** does not take place in this project. This is reinforced by further description by the participant, "*If we have technical problems, we communicate immediately by phone, by video, or have the face to face meeting*". From this statement, it is clear that parties still coordinate through the traditional process, and the **annotation** or **notification system though the model** is not present in the project where participants could get advantage of quicker and effective communication. Moreover, in this project, collaboration is not functionalised and people do not buy-in into the process, rather the participants are reluctant to participate in the process of BIM. The respondent further expressed her thought and described, "*The people who don't know BIM, they think we are the enemy*". This indicates that people are reluctant to participate in the process, and implementation of BIM is difficult and the desired collaboration did not take place in this project. Hence, along with difficulties and inconsistent implementation plan, the coordination and integration in terms of BIM in this project is at a poor level that can be seen from this observation on this project. Eventually, a collaborative project delivery process is not functionalised through the implementation of BIM.

In Table 5-13, the project P09-SA has a score of 11 in terms of coordination and integration, which seems like at a medium level. This project is a 2nd phase of a large project where implementation of BIM is going on. The main driving organisation is one of the lead contractors in the UK and has extensive experience in the implementation of BIM. Participants in this project use **common platform** and **federated model** to produce and **share data**. Also, beside clash detection between the model, timeline and cost schedule is integrated with the 3D model. For instance, a participant P09-RAG described, "*We use the model. We have a plan, plan to work, logistics planning, breakdown areas in terms of design coordination and clash detection, and cost take-off*". This demonstrates that the implementation plan is in place and people use model for various purposes and get advantages. This is supported by another respondent P09-RPT, and he added, "*…we do all the designs in BIM, logistics planning; the programmes is been articulated in BIM, simulative, we have done some quantity take-off from quantity take-off* ". This shows that a considerable level of coordination and integration take place in this project and this has positive impact in the project. For instance, a participant P09-RSH mentioned, "*If you speak to the architect they now do all their projects with 3D Revit… before they start this project they would do everything in 2D*". This shows that **once BIM is used a level where participants can get some real benefits, so that they do not want to go back to the traditional process any more**. There is no offsite manufacturing or real-time data transfer carried out in this project. Therefore, no data coordination is done with the offsite manufacturing plant. These could save time and enhance safety and integrate and **rethink about the construction procedure**. As such, BIM is used in this project to enable smooth operation, where financial benefit is not realised at an extensive level. This is supported by the respondent P09-RAG, and she mentioned "*I don't think it worth any commercial success*". This shows that the success is visible but limited to a certain level in this project. Therefore, the overall observation in this project represents the level of coordination and integration is at a reasonable level where few advantages are gained, and hence the score is at an upper medium level .

From the above observations on three projects, it is seen that there are different activities and feature of the operation of BIM within that people coordinate and integrate between each other. Further, coordination and integration are important to gain advantage from BIM. The relevant scores the level of coordination and integration represents the manner and activities of coordination and integration taking place in the respective projects. Beside the coordination and integration between the parties, a lot of coordination and integration take place with the management of information and the process. At the same time, it can also be observed that the participants are improving the accuracy and overall process, and enhance efficiency through the implementation of BIM, which indicates that such a coordination and integration are connected to the success of the implementation of BIM in particular projects.

5.2.7 Level of BIM on Implementation (Value Level of BIM)

As per the analytic process of GT, the implementation of BIM has been brought under the observation in terms of dimensions and properties of the implementation of BIM in a project. “Level of BIM on implementation” is a category has been explored with the elements of this entity such as properties and dimensions through theoretical sampling. This has been performed to understand the level of BIM implemented in various projects. The properties and dimensions of this category have been explored to render a calibration which is used as a dipstick to measure the level of BIM implemented in various projects. The context of this category represents the stage of implementation of BIM in a project which is determined by some particular attributes. The theoretical sampling of this entity is shown in the following Table 5-14:

Table 5-14: Theoretical sampling of Level of BIM on implementation

Level of BIM on Implementation	
Properties	Dimension(s)
BIM in a construction project Desired feature of BIM	Level of BIM achieved as per government mandate (Basic Level 2 BIM) Level of value achieved through the implementation of BIM (Value level of BIM)

BIM in a construction project

Implementation of BIM in a construction project is an application of new generation of tools and processes into the construction project delivery process. When a project is enabled with BIM, following elements of the project gets new shape than those in a traditional project:

Information: Design information is produced in 3D format and the format of information in terms of deliverables are changed to a digital format. Digital information can be used in various ways and examined with computer for particular purpose, such as clash detection, identifying construction difficulties, and other coordination purposes.

Construction process: Implementation of BIM enables early detection of issues and the construction process can be restructured. For example, adding more prefabrication items in the building is one of the major changes in construction process.

Design coordination: In a BIM-enabled project, participants use a common data repository where they upload or download their information and use the information contributed by other parties. Clash detections and analysis of interfaces are performed by diverse functional parties though the 3D models.

Vocabulary: The vocabulary in a BIM-enabled construction project included new terms which came through the overall modelling process. People are often seen as discussing issues which involve the numerous elements of 3D modelling.

Desired feature of BIM

According to the literature review and the collected data it has been found that implementation of BIM in the individual projects takes place at various levels. Some of the participants in the projects mentioned what level of BIM they were implementing in terms of UK Cabinet Office whereas some of them were describing in terms of the activities they are undertaking within the transition period of the implementation of BIM. The various descriptions of BIM from the participants, necessitate exploring the level of BIM in construction projects through certain attributes which will capture all the possible elements which dominate the level of BIM in a project. To bring the level of BIM in an analytic level and compare various projects with other characteristics, an advanced level of calibration has been performed. The calibration of the implementation of BIM is based on the two major factors, i.e. *Basic Level 2 BIM* as per UK government mandate i.e. *Level 2 BIM components*, and the value creation through the implementation of BIM i.e. e*xtra value components of BIM, i.e. Value level of BIM*. With the combination of these two factors the implementation of BIM in various project has been plotted in this research.

Level of BIM achieved as per the UK government mandate (Basic Level 2 BIM)

The basic level of BIM is the level 2 BIM as per the UK government mandate, which is defined as to attain particular feature of BIM in a project in terms of producing and managing information. The *Basic Level 2 BIM components* are the essentials of BIM defined by the UK

National Building Specification (NBS) (NBS, 2014a) . These are listed in the following Table 5-15.

Table 5-15: Level 2 BIM in various projects

No.	Basic Level 2 BIM components	Scores in projects											
		P01-HW	P02-HA	P03-FA	P04-SS	P05-CC	P06-WS	P07-TH	P08-DM	P09-SA	P10-AI	P11-SF	P12-HC
1	"All parties use their own 3D CAD models, but not necessarily working on a single, shared model."	1	1	1	1	1	1	1	1	1	1	1	1
2	"Any CAD software that each party used must be capable of exporting to one of the common file formats such as IFC (Industry Foundation Class) or COBie (Construction Operations Building Information Exchange)."	1	1	1	1	1	1	1	1	1	1	1	1
3	"Design information is shared through a common file format, which enables any organisation to be able to combine that data with their own in order to make a federated BIM model, and to carry out interrogative checks on it.	1	1	1	1	0	1	1	1	1	1	1	1
4	"Collaborative working".	1	1	1	0	0	1	0	1	1	1	1	
	Total score	**4**	**4**	**4**	**3**	**2**	**4**	**3**	**4**	**4**	**4**	**4**	**4**

Table 5-15 shows the scores against different projects to identify the level of BIM with respect the government mandate. Presence of these elements in a project has been plotted as scores. It is necessary to mention here that a project can only achieve a part if the previous part is achieved by the respective project. If a part is present in a project it scores 1 in the table, and if not, the score is 0. The scoring system is based on 'yes' or 'no' answers according to the available data in various projects. Although it may be an arguable issue whether the weight of the parts should be considered as equal or not, presence of a part in a project is considered as a step of adopting BIM in that project. As such, undertaking more steps means the project is heading towards the Level 2 BIM. A higher score represents the better level of the implementation of BIM. For instance, if a project scores 4, the project has attained Level 2 BIM; if the score is lower than 4, the project is behind the adoption of Level 2 BIM.

The information on this table also presents dimensions of Level 2 BIM in various projects. The table shows that except three projects, rest nine projects scored equal score, i.e. all these projects have achieved Level 2 BIM as per the definition of the Level of BIM. This parameter can be used only in the UK whereas this research has been undertaken across the projects both inside and outside the UK. Along with this vital reason, the variation on this parameter is not visibly significant across the projects; therefore, this parameter is not used to compare with other categories. At this point, to measure the level of BIM in individual projects, the levels of value added to the projects are considered in this study. This value driven level of BIM also represents the extent of BIM implemented in the individual projects. This criterion of measurement is derived through the theoretical sampling of GT approach (see Table 5-16).

Level of value achieved through the implementation of BIM (Value level of BIM)

The value level of BIM in the project is the level of value added in a project through the implementation of BIM. These components were identified through the theoretical sampling of GT study (as described in Chapter 4). Each project was checked whether the project is undertaking these activities or not. Beside the parts of the Level 2 BIM, these activities are identified as the extra value components which is the parameter of the dimension of the 'value level of BIM'. These components are focused on extracting additional value than simply ticking the box of adopting BIM and realising the investment in a project. It has been agreed by number of participants that more extra value components represents the higher level of success. Based on the collected data, the components of BIM which add extra value in the projects are:

1. *Clash detection and reducing clashes*: Clash detection means the digital interactions between the models performed to identify clashes between the functional elements such

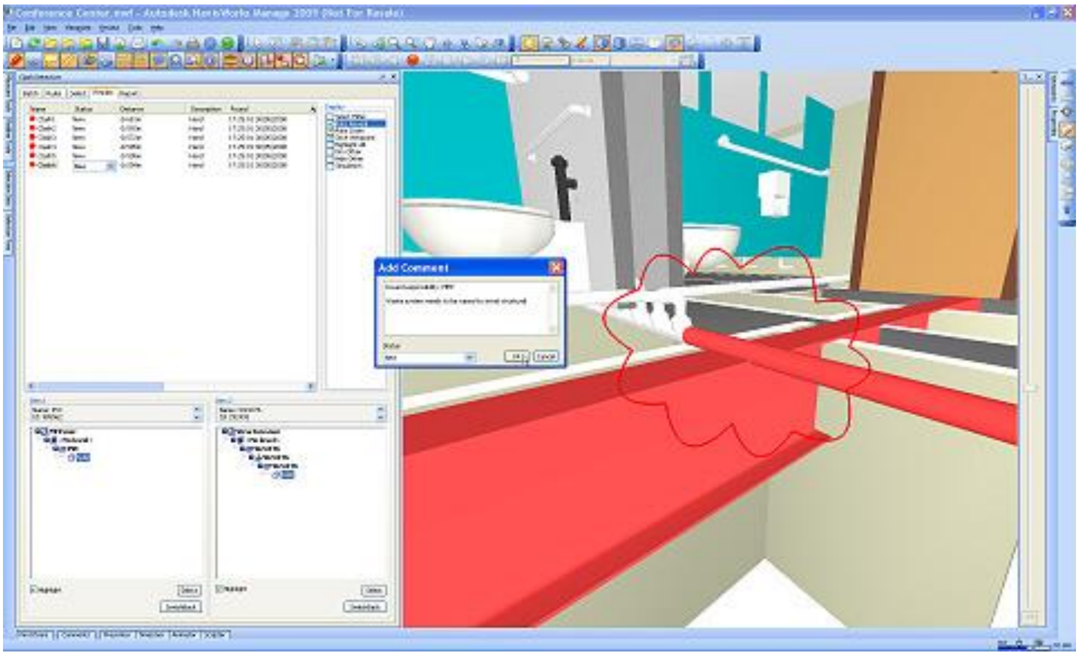

Figure 5-1: An example of clash detection

as architectural and structural elements of the building, plumbing network, electrical wiring, mechanical works, and other miscellaneous works. Once the potential clashes are detected, designs of relevant items are amended accordingly. As the clashes are detected earlier there will be no clashes during the project execution. This will save resources (i.e. money and time), and enhance the level of precision to the building. Thus, clash detection adds value to the project. An example of clash detection is shown in Figure 5-1.

2. *Use the model during the discussions*: Use the model during the discussions means while participants from different functional parties discuss about issues, the 3D models are opened and viewed during the discussion. In this way, participants do not have to depend on the imagination, they can see through the model and consequences of the changes. This activity removes blurriness and builds trust among them. This saves a lot of time of the participants and makes easier to make a decision.
3. *Using common data environment (CDE)*: To manage information and functionalise coordination and collaboration among the parties, all the necessary information is uploaded into a central data repository. People can access, download and use data for

their own purpose. Compared to a single data repository, the meaning of CDE is holding the format of information produced by various parties should be either in a common format or exportable in a common format and interoperable between the models. CDE helps to minimise the organisational and cultural issues in the production and management of information. Thus, a CDE removes the process fragmentation and save time and effort of the participants; in turn, adds value within the project delivery process.

4. *Live information and model*: The information is updated on a regular basis, and the available information is always the latest version, the available information is deemed to be live. Participants get updated information without spending time on gathering information through queries.
5. *Capacity building programmes and realization of investment within the same project*: Sometimes capacity building programmes are undertaken in a way that the knowledge from the learning programmes is used in the next phases of the same project. The participants think that this is an effective way of realisation of investment and hence adding value in the project.
6. *Communication through the model*: People in a BIM project can use the central server as a communication channel by including annotations and making discussions though screen share. People can share ideas and opinions through the model in this way and save time and make quicker decision. This also enhances interactions between the parties.

7. *4D Time lining*: 4D time lining is the integration of programme (construction schedule) with the 3D information model. People can see the progress along with the time line such as a construction rehearsal (see Figure 5-2).

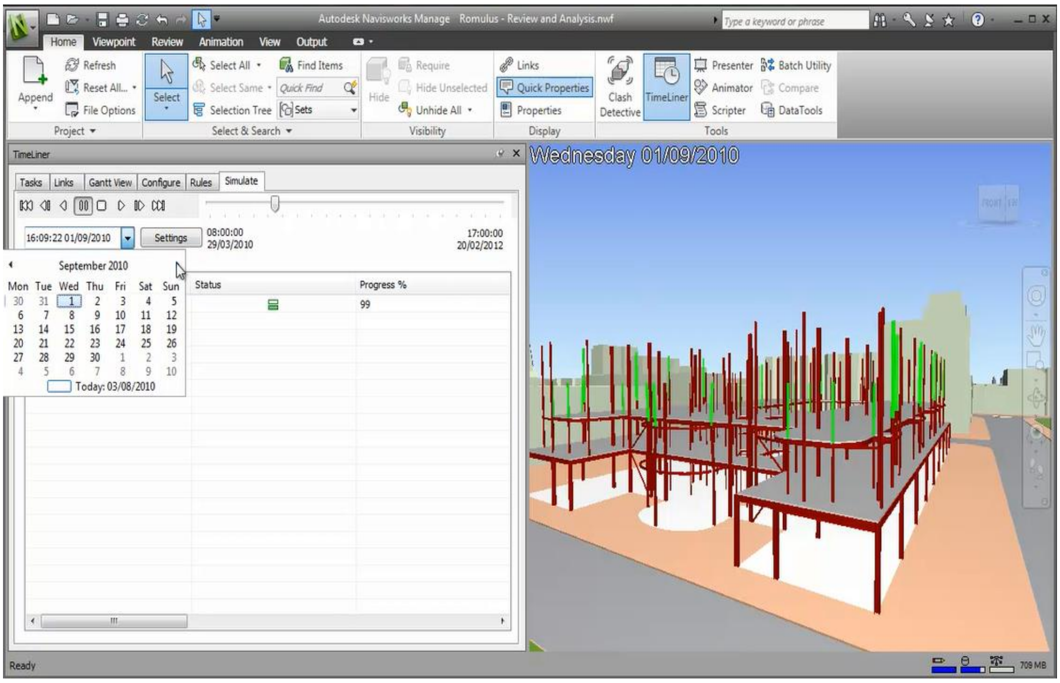

Figure 5-2: Example of 4D time lining in BIM

8. *Offsite manufacturing in own plant, using digital data directly from the model*: By using digital information from the 3D model, items can be prefabricated which come with properties and shapes. Prefabrication through offsite manufacturing allows restructuring the construction procedure and saving time. In another way, offsite manufacturing allows less people on site during construction which enhances safety of the construction site. A complex shape of concrete panel can be suitable to manufacture in the manufacturing machine rather than casting on site. The concrete panels come up with exact size and shape.
9. *Single integrated model (part of BIM level 3)*: A single model which is produced either by integrating all the individual models or producing the multifunctional part from a reference model. This process is a part of Level-3 BIM.
10. *Integration of model and analysis as zone basis*: Individual zones are analysed in terms of various functional model to ensure certain party for work in a particular zone. Parties can assess the feasibility of the work place to undertake certain complex or interdependent works.

11. *5D Cost inclusion*: 5D cost inclusion in an information model enables the participants to view the parts of the building along with the cost. By clicking on the cost one can see the relevant element in the building which is covered by the cost. Figure 5.3 shows an example of 5D cost inclusion in the modelling process.

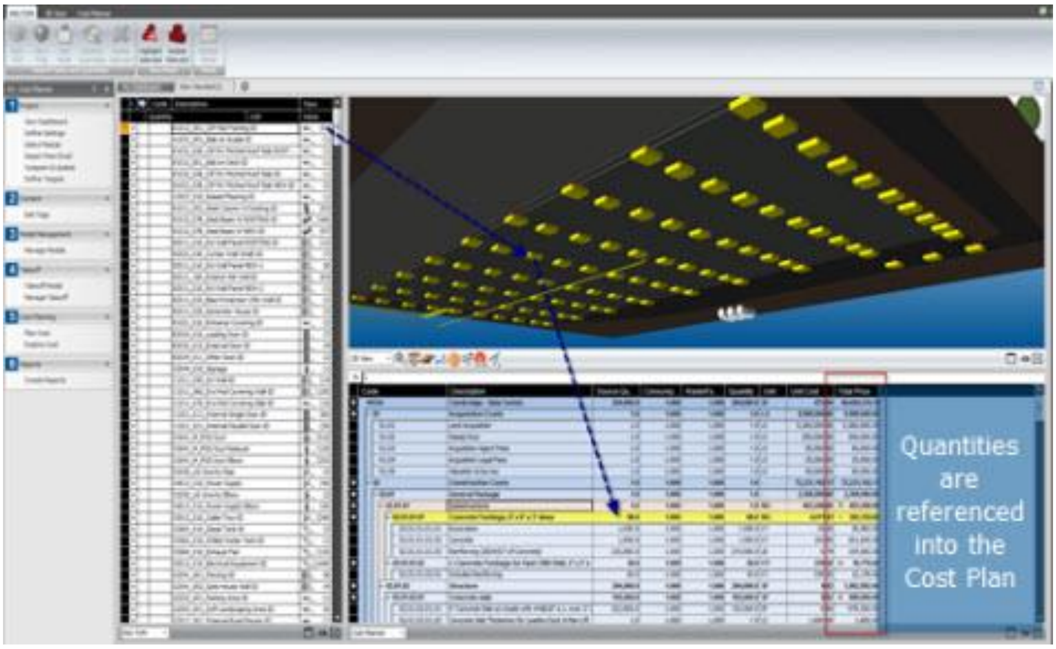

Figure 5-3: 5D cost inclusion in BIM

12. *Use in procurement for tendering*: Procurement department can identify and includes various works in the work packages prior to tender. By using 3D model, contingency items can be reduced by identifying the items precisely and including into the tender.
13. *Use of separate entity models which are saved within the main model*: Separate models for smaller work packages are available in the main model. Participants can use these models to perform any clash detection at a particular interface of the building.
14. *Use of software to add value at extensive level, checking every activity for feasibility of extracting inherent value*: New software packages are examined to add more value into the project by easing construction difficulties or large volume of information.
15. *Real time data transfer*: Real time data transfer is the process of system of acquisitioning field information and transferring through the devices such as mobile or tablets. People can fly around with the device and acquire information from the site and transfer at the same time to the secondary author, i.e. computer. The technologies used in this activity are 3D Laser Scanning or Radio Frequency Identification.

16. *Client access and coordination*: Client access to the model allows viewing the progress or cost information (in some special cases), i.e. how much money has been spent so far by the contractor. This helps to receive an instant feedback from the clients which in turn enhances preciseness and usability of the as-built model.

Table 5-16: Extra value components of BIM across the projects

No.	Value Creating Activities	Presence of value creating activities											
		P01-HW	**P02-HA**	**P03-FA**	**P04-SS**	**P05-CC**	**P06-WS**	**P07-HC**	**P08-DM**	**P09-SA**	**P10-AI**	**P11-SF**	**P12-TH**
1	Clash detection and reducing clashes	1	1	1	1	1	1	1	1	1	1	1	1
2	Use model during the discussions	1	1	1	1	1	1	1	1	1	1	1	1
3	Using common data environment	1	1	1	1	0	1	1	1	1	1	1	1
4	Live information and model	1	1	1	0	0	1	1	1	1	1	1	0
5	Capacity building programmes and realization of investment within the same project.	1	1	0	1	1	0	1	0	1	0	0	1
6	Communication through the model: Central server, annotations and discussions.	1	1	0	0	0	1	1	0	1	1	1	0
7	4D Time lining.	1	1	0	0	0	1	1	1	1	0	0	0
8	Offsite manufacturing in own plant, using digital data directly from the model.	1	1	0	0	0	1	1	0	0	1	0	0
9	Single integrated model (part of BIM level 3).	1	1	0	0	0	0	1	0	0	1	1	0
10	Integration of model and analysis as zone basis.	1	1	1	0	0	1	0	0	0	0	0	0
11	5D Cost inclusion	1	1	0	0	0	0	0	0	1	0	0	0
12	Use in procurement for tendering	1	1	0	0	0	0	0	0	0	1	0	0
13	Use of separate entity models which are saved within the main model.	1	1	0	0	0	1	0	0	0	0	0	0
14	Use of software to add value at extensive level, checking every activity for feasibility of extracting inherent value.	1	1	0	0	0	0	0	1	0	0	0	0
15	Real time data transfer.	1	1	0	0	0	0	0	0	0	0	0	0
16	Client access and coordination	1	1	0	0	0	0	0	0	0	0	0	0
	Total Score	**16**	**16**	**5**	**4**	**3**	**9**	**9**	**6**	**8**	**8**	**6**	**4**

Components are organised in a way that the activities are undertaken by a higher number of projects are listed at the top in the Table 5-16. For example, 'clash detection' and 'use the model during the meetings' are the most frequently performed activities in the projects. In the similar way of scoring the parts on the 'Level 2 BIM' earlier, on a 'yes' or 'no' basis, a project scores 1 if the part is present or activity is undertaken in the project. If the part is not present or the activity is not undertaken in the project then the project scores 0 in the Table 5-16. If a project scores high, it means more value creating activities are undertaken in that project and vice versa.

In the Table 5-16, it is seen that the value level of BIM in various projects are different. Three projects with different level of score covering highest and lowest are discussed to understand the meaning of different scores. The various scores in individual projects represent the extent of value added in the respective projects. For instance, project P01-HW and P02-HA have highest score as 16. A higher score for the value level of BIM represents the desired level of BIM where benefits will be presented in terms of clash reductions between the building elements, progress review, cost review, seamless information flow, and removing construction difficulties.

A project with higher number of value creating activities runs smoothly and coordination between the parties was found improved. Also, the participants in the projects were seen with a good relationship. The participants in the projects mentioned that they are **saving money** through the activities performed in the modelling process. For example, in P01-HW project, a participant P01-RKT motioned, "*…for this project is stage 4D, which basically means we can actually save cost, we can avoid clashes*". This shows that **clashes are avoided** and costs are saved through BIM; and **saving cost through the BIM activities** are adding value to the project indeed. So, it is not only adding value to the project, but also improving the project delivery process. This is supported by the respondent P02-RMB and he mentioned, "*Now you work in this stage. You shouldn't have any clashes, you shouldn't have any problem. I think it (BIM) worked on very well*". This shows that how BIM made project execution easier without incurring any problems or construction difficulties. In these two projects, all the value adding activities or elements are mentioned in the table. This means that a higher level of value is added in either of these projects. In contrast, the score in the project P05-CC is lowest as 3. In this project, less number of activities are carried out to add value in the project, i.e. less value is added in this project through the implementation of BIM.

The project P09-SA has a medium score of 8. In this project, a number of value adding activities are carried out. Activities such as **clash detections**, **4D time lining, and 5D cost inclusion** are performed in this project which enables extracting values up to a certain level but not many benefits beyond that. This is supported by the respondent P09-RAG who mentioned, "*I think for us the success of the project will be we have sufficient staff members coming out the back end of the project, they are happy to use it. We would think it will automatically go to the next project and obtain benefit, I think that will be our success. I don't think we can really measure apart from, I don't think it worth any commercial success. We really apply on a project to get of it ready familiar with it*". This statement clarifies that the participants are still getting used of it and are awaiting further benefits to achieve the desired success. It also indicates that extracting value or adding benefits represents the success of the implementation of BIM. The overall phenomena reflect of having medium score of the project.

High score of a project is higher in terms of value addition indicates that the project has undertaken lots of value creating activities, which is an indication of higher success of the implementation of BIM and vice versa. This value level is the ultimate consequence of the activities and events within the implementation of BIM in any projects, i.e. the value level is influenced by number of activities performed by the participants. The participants carry out these activities which are guided through various aspects such as instructions in implementation plan, the existing information management system, existing skills and supports, and goals for the project and individual organisations.

5.2.8 Interactions between the Parties

Frequent interactions take place among the participants in BIM-enabled projects in various ways such as daily work, problem solving, client's change orders, pragmatic issues, upcoming issues, and information updates. Sometimes, participants meet each other through regular pre-set meetings or as per requirement for particular issue. Interactions between the parties in a BIM project occur in a technology-driven way. The interactions also occur between the parties where BIM attracts the central attention. Technology-based interactions are the most frequent interactions that happen in a BIM project.

From the respondents' view, projects are seen as interactive but the nature and of the interactions vary from project to project. In order to get an in-depth understanding of the nature and the level of interactions in the BIM-enabled projects, the properties and dimensions of this notion were identified through theoretical sampling. Table 5-17 shows the theoretical sampling of "Interactions between the parties":

Table 5-17: Theoretical sampling of "Interactions between the parties"

Interactions between the parties (Catgeory-16)	
Properties	Dimension(s)
Various interactions and drivers	Number of individual type of interaction or drivers of interactions present in a project

Various interactions and drivers

Different kinds of interactions take place in the individual projects. It has been found that the most interactions are related to the context and settings of the individual projects. In a particular project, a unique nature of interaction is not unusual when the interaction is embraced by value planning. Following are the descriptions of interactions that will elucidate the various interactions and potential drivers of interactions in the BIM projects:

Within individual work zones as defined in the model

When people from different functional packages are supposed to work in a same area, all kinds of works in that area are grouped as a single entity in the model. Each area is taken off from the model and brought under observation. Potential clashes and difficulties in constructability during work can be reviewed with the help of the intelligent model. Interactions between the models are performed to visualise the clashes and other potential issues such as workers' accessibilities and safety. The participants can see the detail and discuss the matter between each other and work together. It makes more transparent environment within the supply chain.

Frequent interactions driven by relationship

In some cases, interactions are prompted by relationship and support from the main contractor. Subcontractors are encouraged to develop extra interest among them to use the model. The more they use the model, the more conversations and interactions take place, and relationship builds up among the parties. The main contractor provides the necessary facilities to the subcontractors to use the model. Learning programmes and capacity building activities are enabled by participation in the 3D model based project delivery process. People can share ideas in between them during the sessions.

Pragmatic issue visualisation in the models

In most cases, pragmatic issues are solved by the parties with the help of visualisation through the models. The parties can discussion the matter on the table. It does not require the parties visiting the site physically. This kind of interactions occurs frequently in the BIM-enabled projects.

During clash detections

Clash detections are the most frequent interactive events. During the clash detections, interactions are performed between the individual functional models. Issues and facts are found in clash detections drive interactions between the people gathered from diverse functional disciplines.

Interactions between the members at different time zones

In a project, some of the supervisors work away from the site, even outside the state. Obviously, there is some bilingual people work with the foreign team members. It has been mentioned by the participants that a lot of new ideas are implemented at site which came from the people living outside the state. It has been mentioned by the participants it is a great feeling for them that the people from other states are working and smoothly coordinating with the project team and meeting the particular expectations. Communications have been found as the key point to establish this kind of relationship and enable the effective interaction. It makes easier to coordinate with increased confidence and the presence of a common platform such as the CDE.

Offsite manufacturing coordination

In particular cases, interactions are functionalised by new activities in the project delivery process. Particularly, in H01-HW, P02-HA, and P10-AI projects, there are in-house manufacturing facilities which connect the relevant parties involved through the item to be manufactured. For instance, an item such as an operation room may involve water pipe, air conditioning, oxygen supply tank and piping network etc. While manufacturing the major concrete elements, all the remaining items in the room are considered, and relevant data is fed into the model before going ahead with actual manufacturing. Otherwise, there may be a space related issue during fitting the manufactured item along with other building elements. Coordinations are done prior to feed the digital information into the manufacturing machine. Individual models are cross checked carefully during this activity.

Team focused interactions, sharing knowledge and skills

Some people find difficulties to integrate with the other people in a new technology platform. To minimise this issue, early sessions relevant to the modelling process are organised to go through the model and the rules to be followed within the project. Sometimes, the rules are set on a sub team basis with detail instructions. A comment from a respondent is, "*We just need to review set down the model go through and everybody comes in house then view is to whether it can be done this way or that way better to do this better to do that and again coming back to collaboration an open communication*". This shows that everyone is involved and interacted to derive the best solution of the issues. Most of the sessions with BIM are carried out with visualisations of interactions between the structural and other functional elements. An interpretation of information between the functional elements enhances confidence, saves time and ensures safe working environment.

Construction procedure rehearsals

Construction works are organised to see through computer simulation and rehearsals can be performed several times. In this way, potential hazards and construction difficulties can be viewed. Also, through the visualisation, participants can have better understanding of the works upfront and discuss to avoid inconsistency. Thus, visualisation provides a clear understanding and fosters frequent interactions among the parties and removes the blame culture within the industry.

Interactions between the parties often take place in a centralised manner and more dialogs take place when the issues are discussed through the model. Once the solution is done through the visualisation in the model, the participants become free from uncertainty of the problem. Dialogs are made in the meetings related to the phenomena can be attested through the model. Once the model is updated after amendment, participants get informed via model notifications.

Hence, the mode of communication and interactions between the participants become more dynamic, which is underpinned by the intelligent model.

Problem solving through the model

During the problem solving process, the interactions take place as per the guidance in the implementation plan and subsequently agreed by the parties. For example, when a problem occurs in a project, the first task is to retrieve who owes the problem; then someone of the existing team provides notice to the respective party to arrange a conversation on the issue. In some particular cases, problems are kept on-hold until the date of regular forums where all the engineers and consultants become available in that forum. An open communication is highly demanding for these kinds of interactions.

Multi-disciplinary coordination and collaboration

In a construction project team, critical interactions often take place. The multi-functional parties from different organisations working in a project have to manage their parent organisations and the rules and regulations of the project at the same time. In such kind of situation conflict of interests is usual. As mentioned by a number of respondents, these conflicts lead the deployed people from diverse disciplines in difficult situations and dilemmas. People in the projects interacting with each other may have different cultural paradigms. According to the respondents, the key drivers to avoid the dilemmas during the interactions are personal skills, open communication, availability of information, empathy, and compromise. Such kind of interaction is not much different from a traditional project.

Face to face, video calls, phone calls, and email

Interactions are driven by different forms of communication in a BIM project such as phone calls, emails, face to face meetings, and video conference though screen share. However, it has been claimed that no other forms of communication is better compared to face to face interactions in terms of effectiveness of communication in a construction project. A comment from a respondent P06-RAC about the claim was "…*in this industry there is nothing rather than face to face contact, talking things through, as long as right people in the right room, you can go on and have a look on the issues*…". This demonstrates that a face to face interaction is more effective than any other means to make it more effective.

Accessing and using common data environment (CDE)

People interact with each other frequently when they exchange documents among themselves. Architect and designers collect data and then pass those data to the engineers and the site people to work. The data is then passed from the site personnel to the owner. In the traditional process, there is a lack of trust when such kind of interaction takes place. It has been described by a number of participants that in a BIM project, data is open to all parties in a server. People can get access to and frequently use the data from the central repository, and there is no scope of mistrust between the parties.

It has been mentioned by a respondent that there is a changed and controlled behaviour of the people with the data when participants interact within CDE. Interactions occur between the parties during planning, communication, and other things such as support data, developing and inclusion of it. The central data management system is used in the project to manage data. Data is uploaded by the individual parties on the central data management system from where people can share and use data for their own purpose.

Model annotations and notifications

In some cases if there is any issue or clashes within building element that are found from clash detections, annotations are included in the model and people are notified via model. For instance, the respondents in a project mention that the interactions between the parties were different to a certain degree than in a traditional project. The designers' willingness to share models and participating in coordinating activities are the major differentiations in this BIM project. As BIM is not contractual in this project, the project has not started with a complete model. Drawings are received from the designers and incorporated with the model in progress. The model progresses as per the progress of the project. Levels of details are provided in the model for certain purposes which are coordinated with the relevant parties. There is a relationship between the level of willingness of the designers to share the model and the completeness of the model. The lead contractor is not detrimental to the other parties in terms of BIM. There is an effective collaboration functionalised among the participants in the project, which is considered as a win-win condition.

Number of individual type of interaction or drivers of interactions present in a project (level of interactions)

Individual projects receive different scores based on the varieties of interactions and potential drivers of interactions (see Table 5-18).

Table 5-18: Interactions and drivers of interactions in various projects

No.	Interactions and drives	Projects											
		P01-HW	P02-HA	P03-FA	P04-SS	P05-CC	P06-WS	P07-TH	P08-DM	P09-SA	P10-AI	P11-SF	P12-HC
1	Multi-disciplinary coordination and collaboration	1	1	1	1	1	1	1	1	1	1	1	-
2	Within individual work zone as defined in the model	1	1	0	0	0	1	0	0	0	0	0	-
3	During clash detections	1	1	1	1	1	1	1	1	1	1	1	-
4	Subcontractors use the model from the lead contractor	1	1	1	1	0	1	0	0	0	1	1	-
5	Pragmatic issues visualisation in the models	1	1	1	1	0	1	1	1	1	1	1	-
6	Offsite manufacturing coordination	1	1	0	0	0	1	0	0	0	1	0	-
7	Sub team based work package for critical activities	1	1	0	0	0	1	0	1	1	0	0	-
8	Construction procedure rehearsal, identifying challenges	1	1	0	0	0	0	0	0	0	0	0	-
9	Team focused interactions, sharing knowledge and skills	1	1	1	0	1	1	1	1	1	1	1	-
10	Regular model review	1	1	1	0	0	0	1	1	1	1	1	-
11	Face to face interactions between disciplines	1	1	1	1	1	1	1	1	1	1	1	-
12	Problem solving through the model, on table	1	1	1	1	1	1	1	1	1	1	1	-
13	Model annotations, notifications	1	1	0	0	0	1	0	0	0	1	0	-
14	BIM implementation plan based meetings	1	1	1	0	0	0	0	1	1	1	1	-
15	Interactions by relationship and cultural empathy	1	1	0	0	0	0	0	0	1	0	0	-
16	Accessing and using common data environment to solve a problem	1	1	1	0	0	1	0	1	1	1	0	-
17	Fully technology-driven interactions, screen shares	0	0	0	0	0	1	0	0	0	0	0	-
18	Interactions between the members of different time zones	0	0	0	0	0	1	0	0	0	0	0	-
19	Video conference	0	0	0	0	1	1	0	0	0	0	0	-
	Total score	16	16	10	6	6	15	7	10	11	12	9	-

From Table 5-18, it is seen that various projects have different scores in terms of interactions and drivers in the individual projects. It is desired that interactions will evolve from the self-motivated people and reinforced by the process. It was described by the respondent P01-RSK that applying the pre-set interactions might be too much complicated. The desired group of people in a BIM project have been identified proactive, self-motivated, and dynamic. A project leader described the desired people to cause frequent interactions in a BIM project as, "*You need people who light the issues are switched on and who are motivated to pick up the phone, tell them the models are ready, you need to work on the detail and take the snapshot*". This shows that interactions are prompted by number of drivers, issues and events and happened among the people within the projects. A higher score in the project means that a lot of interactions take place between the participants in the respective project. For instance, the project P02-HA has a score of 16 which represents very much frequent interactions take place in this project. This is supported by the respondent P02-RGC, and he described, "*This is a very much personally interactive project*". This statement clearly demonstrates the nature and frequency of interactions within the projects. In contrast, the project P04-SS and P05-CC both have the lowest score of 6. It means these projects involve fewer interactions between the participants. Such a phenomenon is supported by the respondent P04-RMT, who mentioned, "*At the end of the day they still want to meet the deadline producing 2D drawings rather than sharing the models with each other, yeah*". This reveals that this project is not involved with **sharing the models**, and the desired interactions do not occur from the consequences of **sharing or accessing the information models**. This also demonstrates that such as low sore represents the poor picture of modelling process where participants do not integrate between each other. This is reinforced by the respondent P05-RZY who said, "*They think that we are the enemy. Yeah, we are the enemy because the new ways, the new management styles make them have to change but you know not everyone wants to change if they can earn same money they don't wanna change*". This shows that in this project people are not cooperative to participate in the new way of collaboration where they could be benefited from more interactions in terms of both people and models and enhance preciseness of process and product. This justifies the picture behind the poor scores in terms of interactions between the parties.

It has been seen that interactions between the parties in a project occur during exchanging information and opinions. This exchange of information or opinion is prompted when parties have a certain level of understanding. The understanding, skills or capacity of carrying out the modelling process impact the interactions, coordination, or value level of BIM. However, lack of skills may discourage individual to interact with others. More capacity building activities may boost up the outcomes but it also indicates the lack of desired skills in a particular project which may have negative impact up to a certain extent.

5.2.9 Relationship and Influential Factors among the Categories

The summary of the findings are as follows:

- The dimension (i.e. scores) of categories are found varied across the projects, in other words these are the variables in the project that influence the implementation of BIM and overall activities in a project. The scores are related to other parameters in the project. From the analyses and observations it has been found that a category may be related to one or more categories or may influence one or more categories, or a category may be influenced by one or more categories.
- It is indicated that the actions of a leadership in a project is related to a number of factors and influence them. The factors are:
    a) BIM implementation plan and protocol
    b) Data exchanges and accessibilities
    c) Value optimisation
    d) Capacity building programmes
- The outcomes in a project in terms of BIM, i.e. coordination and integration, value level of BIM, and interactions between the parties are the consequences of the above four factors. The consequences depend on the state of the factors in the respective projects. These factors represent the state of the implementation plan and protocol, and, or, value proposition in a project, existing skills and capacity building supports, and the information management system enabled in the projects to share information and to perform communications.

- Capacity building programme in a project has contribution to the 'coordination and integration' in a project but not to the other outcomes (i.e. value level of BIM, and interactions between the parties).
- The influence may be caused by individual or combined actions of the factors. However, these factors (variables) are the elements of the process of BIM, which build culture of the project-based organisations. While BIM is implemented in a project, these elements adopt certain characteristics based on the activities and events within them which have come through the presence of these activities or events in the projects. Based on this phenomenon, various scores are the numeric summary of the phenomena for individual variables for the respective projects. The numeric scores can be used to verify the influential behaviour between the variables which are inherited by the culture of the individual projects.

The findings have been found from the GT study have been brought under validation process through an independent qualitative method such as regression analysis and correlation test. The independent verifications by triangulations are discussed in the following sections in this chapter.

5.3 Data Interpretation by Correlation Test and Regression Analysis

From the GT study, a number of categories have been found. Those are related to the elements of culture in construction project-based organisations. As a way of methodological triangulation, regression analysis has been performed to validate the findings in the GT study. Data related to the derived categories in the GT study are as follows (see Table 5-19):

Table 5-19: Dimensional data for various categories

Project	Value Level of BIM	Coordination and integration	Interactions between the parties	Data exchanges and accessibilities	Capacity building programme	BIM implementation plan and protocol	Value optimisation	Leadership
P01-HW	16	20	16	12	11	8	14	10
P02-HA	16	17	16	12	8	8	12	9
P03-FA	5	9	10	4	4	4	4	7
P04-SS	4	5	6	3	5	1	2	1
P05-CC	3	4	6	2	2	1	2	2
P06-WS	9	17	15	7	4	7	8	6
P07-TH	4	6	7	2	1	2	3	3
P08-DM	6	12	10	5	5	7	6	7
P09-SA	8	11	11	6	6	7	8	9
P10-AI	8	10	12	8	1	5	7	6
P11-SF	6	10	9	7	1	4	4	6

In various construction projects, it has been found that the decision on the implementation of BIM is made by the lead organisations. When the decision is made to implement BIM in a project, the people undergo in a project delivery process which is underpinned by BIM. From articulating BIM implementation plan and protocol till the desired development of the active process of coordination and integration, there are several factors which drive the coordination and integration or value to be added in the project. Value is added in a BIM project in various ways such as saving time, money or effort, or, enhancing preciseness and usability of the information model to be used during the operation period of the building. As such, the 'Value level of BIM' results from the various activities and events in a project through the process of modelling. Therefore it is a dependent variable for a project where the whole life cycle of the project is considered. Similarly, 'Coordination and integration' and 'Interactions between the parties' in a project take place in a project when the people use certain technology through a defined process to carry out the project delivery process. The overall process potentiates an improved way that will ensure the best value for the ultimate product. Based on the findings, variables such as 'Value level of BIM', 'Coordination and integration' and 'Interactions between the parties' are the ultimate outcomes through the implementation of BIM in construction projects. Especially, the outcomes 'Coordination and integration' and 'Interactions between the parties' represents how people work in a project and show lead the culture in the BIM-enabled construction projects. These three categories (variables) are ultimate dependent variables in Table 5-19.

At first correlation test has been performed to investigate whether the variables found in BIM projects in terms of culture and the implementation of BIM are related to each other or not. Following results have been obtained from the Pearson's correlation test performed with the data gathered in the study (see Table 5-20):

Table 5-20: Results from the correlation test

	Value Level of BIM	Leadership	Coordination and integration	Data exchange and accessibilities	Capacity building programme	BIM implementation plan and protocol	Value optimisation	Interactions between the parties
Value Level of BIM	1							
Leadership	0.781	1						
Coordination and integration	0.903	0.827	1					
Data exchange and accessibilities	0.923	0.767	0.764	1				
Capacity building programme	0.779	0.634	0.71	0.637	1			
BIM implementation plan and protocol	0.813	0.922	0.919	0.708	0.6466	1		
Value optimisation	0.975	0.803	0.917	0.876	0.8332	0.8582	1	
Interactions between the parties	0.916	0.826	0.963	0.795	0.6371	0.9039	0.916	1

From the Table 5-20, this can be observed that there are relationships existing between the variables. However, the relationships between the variables are not similar. If the correlation coefficient value between the variables closer to 1 then the relationship is strong and vice versa.

For instance, there is a strong relationship between value optimisation and value level of BIM with the coefficient of 0.975. On the other hand capacity building programme has a cooperatively weaker relationship with leadership (coefficient is 0.634) or data exchanges and accessibilities (coefficient is 0.637). Hence, there is an existing relationship between the variables identified in the GT study, which also ports the findings in the GT study. To understand the nature of relationship or the influence of variables to the outcomes in a project is examined by regression analysis.

Both forward and backward regression analyses have been performed with the available data, which indicates that certain variable is related to one or more variables and has influence to those variables. It has also been found that a variable may be independent with respect to certain variables, for example, when the particular variable influences one or more than one variables. At the same time, this independent variable might be dependent to other one or more variables. For instance, a project leader is an identifiable person who designs the implementation of BIM for a project. The 'Leadership' may influence the factors such as 'BIM implementation plan and protocol' and 'Data exchanges and accessibilities' in that particular project. Here, these two variables are the dependent variables. Thus, the variables 'BIM implementation plan and protocol' and 'Data exchanges and accessibilities' are influenced by the independent variable 'Leadership'. However, the variables, 'BIM implementation plan and protocol' and 'Data exchanges and accessibilities' may influence 'Coordination and integration' or 'Value level of BIM' in a project. In this case, 'BIM implementation plan and protocol' is an independent variable with respect to the dependent variable 'Coordination and integration'. To identify the influence and relationship within the variables found in this study regression analysis is performed. The regression analysis will clarify-

- the relationship between the variables, and
- the influence of variable(s) to other variable(s).

Influence of, or, Relationship between the Categories

Regression analysis has been performed between the variables as an independent manner to cross examine the findings from GT study. Followings are the results from the regression analysis:

Leadership (independent) and other variables (dependent with respect to leadership)

Table 5-21: Results of regression analysis between leadership and other variables

Dependent variable(s)	Independent variable(s)	R-squared value	*P value*	*Significance f*	Comments
BIM implementation plan and protocol	Leadership	0.85	0.00001 < 0.05	0.00001 < 0.05	Accepted
Data exchanges and accessibilities	Leadership	0.40	0.03600 < 0.05	0.036 < 0.05	Accepted
Value optimisation	Leadership	0.73	0.00084 < 0.05	0.0001 < 0.05	Accepted
Capacity building programme	Leadership	0.63	0.00343 < 0.05	0.003 < 0.05	Accepted

In Table 5-20, determining the influence of or, relationship between the variables are based on the *P-value* and *Significance f* obtained from the regression analysis. The influential model of the variables is represented in the following Table 5-21:

Table 5-22: Simple regression models with the influence of leadership

Dependent variable(s)	Independent variable(s)	Simple regression Model
BIM implementation plan and protocol (BIPP)	Leadership	BIPP = -0.184 + 0.85 * (Leadership)
Data exchanges and accessibilities (DEA)	Leadership	DEA = 0.461 + 0.95 * (Leadership)
Value optimisation (VO)	Leadership	VO = -0.543 + 1.151 * (Leadership)
Capacity building programme (CBP)	Leadership	CBP = 0.247 + 0.67 * (Leadership)

Results from simple regression analysis demonstrate that the leadership context in terms of the implementation of BIM is related to number of variables, i.e. ‘BIM implementation plan and protocol’, ‘Data exchanges and accessibilities’, ‘Value optimisation’, and ‘Capacity building programme’, and influence them.

In Table 5-22, it is seen that number of factors in a BIM project are influenced by leadership context. Among the regression models, it can be observed that the coefficient 1.151 (closer to 2) is the highest value in the model with ‘Value optimisation’. This means that the leadership context is highly influential to the value optimisation in a BIM project. This is supported by a respondent P04-MT and he said, “*I am not the project manager or design manager myself, I don’t know the internal strategy they are working. It is trying to find what the end result to them, what they want from BIM process*”. This statement shows that planning of desired outcome, such as the desired goal to be achieved from the implementation of BIM, significantly depends on the person at the top of the project management, i.e. the project leader. Similarly, the other models also demonstrate that the leadership context is influential to the internal factors ‘BIM implementation plan and protocol’, ‘Data exchanges and accessibilities’, and ‘Capacity building programme’ in a BIM project. The coefficient for ‘Capacity building programme’ is the lowest among the models. This means that in a BIM project, the project leader is less influential to the capacity building activities than the level of influence to the other factors mentioned in Table 5-22.

Influential factors for ‘Coordination and integration’ and ‘Value level of BIM’ and ‘Interactions between the parties’

Regression analysis is also performed in both simple and multiple ways to check the influences of the internal factors on the ultimate outcomes of the implementation of BIM, i.e. attaining a collaborative delivery process through improved coordination and integration, and achieving optimum value to both process and product. Accordingly, in this case, ‘Coordination and integration’ and ‘Value level of BIM’ are the dependent variables, however the other four variables i.e. ‘BIM implementation plan and protocol’, ‘Data exchanges and accessibilities’, ‘Decision making process’, ‘Value optimisation’, and ‘Capacity building programme’ are independent variables. Simple and stepwise multiple regression analysis have been performed for ‘Coordination and integration’, ‘Interactions between the parties’ and ‘Value level of BIM’ to check whether these three variables are related to, or, influenced by the four independent variables (internal factors) or not. Results from analyses are shown below:

Simple regression ‘Value level of BIM’ with other variables

Results of simple regression analysis for ‘Value level of BIM’ have been shown in the Table 5-23 below:

Table 5-23: Relationship and influence, simple repression: Value level of BIM

Dependent variable(s)	Independent variable(s)	R-squared value	*P value*	*Significance f*	Comments
Value level of BIM	Data exchanges and accessibilities	0.92	0.000003 < 0.05	0.000003 < 0.05	Accepted
	Capacity building programme	0.61	0.0047 < 0.05	0.0047 < 0.05	Accepted
	BIM implementation plan and protocol	0.66	0.0023 < 0.05	0.0023 < 0.05	Accepted
	Value optimisation	0.95	0.000005 < 0.05	0.000005 < 0.05	Accepted

The simple regression models are tabulated below (see Table 5-24):

Table 5-24: Simple regression models with influence on value level of BIM

Dependent variable(s)	Independent variable(s)	Simple regression Model
Value level of BIM (VLBM)	Data exchanges and accessibilities (DEA)	VLBM = 0.15 + 1.22 * (DEA)
Value level of BIM (VLBM)	Capacity building programme (CBP)	VLBM = 2.90 + 1.10 * (CBP)
Value level of BIM (VLBM)	BIM implementation plan and protocol (BIPP)	VLBM = 1.08 + 1.35 * (BIPP)
Value level of BIM (VLBM)	Value optimisation (VO)	VLBM = 0.691 + 1.11 * (VO)

In Table 5-23 and Table 5-24, results from simple regression analysis show that value level of BIM is individually influenced by number of factors (these factors are also influenced by the factor leadership). Among the factors, while considered to influence individually, for example, the model with 'Value level of BIM' has a coefficient 1.11. The coefficient is close to 1. This indicates that 'Value optimisation' in a project influences the 'Value level of BIM' of that project. This is supported by number of participants in various projects. For instance, a respondent P01-RAF mentioned, "*to take quantities from the site so it is very regular kind of recording which are remote based but we are looking at doing on site mark over which we can use 3D. That is kind of process we are going through… it will benefit us in our end valued construction, in terms of all of our precast units*". This statement shows that the intention of use new software to save time is planned through taking of quantity of materials from the 3D models. This is a desired value in the delivery process which reflects through the offsite manufacturing process. This activity ultimately saves time and enhances preciseness of the product by rethinking the construction process. Hence, 'Value optimisation' in a BIM project influences the 'Value level of BIM'. Similar influences are caused by the factors 'Data exchanges and accessibilities, 'Capacity building programme' and 'BIM implementation plan and protocol' individually which can be seen from the regression models mentioned in Table 5-24.

Stepwise multiple regression: Value level of BIM (dependent) with other independent variables

In stepwise multiple regression analysis, the highest P value means the lowest significance, and the variable is removed from the multiple regression data. Further analysis is performed with rest of the variables. This process is followed until the P value is found less than the common alpha level 0.05.

Results obtained from stepwise regression analysis are tabulated below (see Table 5-25 to Table 5-27):

Table 5-25: Step-1 of multiple regression analysis for value level of BIM

Dependent variable(s)	Independent variable(s)	Adjusted R-squared value	*P value*	*Significance f*	Comments
Value level of BIM	Data exchanges and accessibilities	0.97	0.0301	0.00018 < 0.05	Retained
	Capacity building programme		0.3208		Removed
	BIM implementation plan and protocol		0.1344		Retained
	Value optimisation		0.0314		Retained

Table 5-26: Step-2 of multiple regression for value level of BIM

Dependent variable(s)	Independent variable(s)	Adjusted R-squared value	*P value*	*Significance f*	Comments
Value level of BIM	Data exchanges and accessibilities	0.97	0.03816	0.000003 < 0.05	Retained
	BIM implementation plan and protocol		0.08095		Removed
	Value optimisation		0.00274		Retained

Table 5-27: Obtained multiple regression results for 'Value level of BIM' from the final step

Dependent variable(s)	Independent variable(s)	Coefficient	Adjusted R-squared value	*P value*	*Significance f*	Comments
Value level of BIM	Intercept	0.21846	0.96	0.7097	0.000001 < 0.05	-
	Data exchanges and accessibilities	0.50990		0.0473 < 0.05		Accepted
	Value optimisation	0.68461		0.0076 < 0.05		Accepted

In Table 5-27, it is seen that the adjusted *R-squared value* is 0.96, and both *P-value* and *Significance f* is less than the significance level 0.05. Therefore, the result of the regression analysis shows that there is a linear relationship between 'Value level of BIM' and other two variables i.e. 'Data exchanges and accessibilities' and 'Value optimisation' in BIM enable projects; and 'Value level of BIM' is significantly influenced by these two variables.

The regression model (rounding coefficients up to two decimal points) is-

Value level of BIM = 0.22 + 0.51 (Data exchange and Accss.) + 0.68* (Value optimisation)*

Therefore, the indication of the above model describes that 'Data exchanges and accessibilities' and 'Value optimisation' have combined or individual influence on 'Value level of BIM' in a BIM-enabled project. A participant mentioned, "*…every week our document control are just ask to press the button and update any changes that are been made to all of our subcontractors' models. So, within that main model you will have your CM value*". This shows that the data exchange system contains the model which is the ultimate intelligent model and improvement of configuration management is done through the data exchange accessibilities system.

An improved data exchanges and accessibilities system can add value by saving time during the process through various activities such as annotations and communications though the models for solving problems within a CDE. This is supported by a participant P01-RSK, and he asserted, "*One other thing is we found digital times people use that is amazing not to get around the table, so they will try an exchange information through the models and resolve problems*". This shows that a communication through the information management system can save time and effort for the participants for certain issues during the project delivery process. Values are added in various ways within the data exchanges and accessibilities system in a BIM project such as 4D time lining, exchanging data between the model and the offsite manufacturing, and getting live information for continuing work by the individual parties. Thus, a significant value is added, a lot of time is saved, and accuracy is enhanced through an improved data exchanges and accessibilities system in a BIM project.

Simple regression 'Coordination and integration' with other variables

In a similar way, both simple and multiple regression analysis have been performed for 'Coordination and integration' with other variables.. Following Table 5-28 and 5-29 show the results and simple regression models obtained from the simple regression analysis:

Table 5-28: Relationship and influence (simple regression): Coordination and integration

Dependent variable(s)	Independent variable(s)	R-squared value	*P value*	*Significance f*	Comments
Coordination and integration	Data exchanges and accessibilities	0.78	0.00028 < 0.05	0.00028 < 0.05	Accepted
	Capacity building programme	0.50	0.0143 < 0.05	0.0143 < 0.05	Accepted
	BIM implementation plan and protocol	0.85	0.00006 < 0.05	0.00006 < 0.05	Accepted
	Value optimisation	0.87	0.00003 < 0.05	0.00003 < 0.05	Accepted

Table 5-29: Simple regression models of influence on coordination and integration

Dependent variable(s)	Independent variable(s)	Simple regression Model
Coordination and Integration (CAI)	Data exchanges and accessibilities (DEA)	CAI = 2.90 + 1.31 * (DEA)
Coordination and Integration (CAI)	Capacity building programme (CBP)	CAI = 5.92 + 1.16 * (CBP)
Coordination and Integration (CAI)	BIM implementation plan and protocol (BIPP)	CAI = 2.31 + 1.76 * (BIPP)
Coordination and Integration (CAI)	Value optimisation (VO)	CAI = 3.19 + 1.23 * (VO)

From Table 5-29, it can be seen that ‘Coordination and integration’ is individually influenced by a number of variables, i.e. ‘Data exchanges and accessibilities’, ‘Capacity building programme’, ‘BIM implementation plan and protocol’, and ‘Value optimisation’. From these modes, a model is discussed to understand how a variable influence the other one. For instance, the model with ‘BIM implementation plan and protocol’ has a coefficient of 1.76 which is closer to 2, and this is the highest coefficient among the other coefficients in the models. This means that under a certain condition, the factor ‘BIM implementation plan and protocol’ individually influences ‘Coordination and integration’ more than other variables shown in the Table 5-29. Hence, it is important to design BIM implementation plan and protocol to functionalise coordination and integration in a BIM project. This is supported by P01-RSC who mentioned, “*What we did one is we set up a BIM protocol, how everybody work on file or information, so could all be brought together in a collaborative format, what would we work, what document management system we would use collate that, and how will we view and report against the model which is been developed*”. This statement clarifies that BIM implementation plan and protocol guide and reinforce the participants to undergo an active coordination and integration process where the people become truly collaborate. This statement further indicates the enhanced preciseness of the BIM implementation plan and protocol within a project is reflected through the coordinations takes place among the participants. For instance, a respondent P01-RAF mentioned, "*We are trying to integrate the model, as much as we can, and if we have any coordination issues on site, we generally open up the BIM model*". This statement describes the clear intention and planning to integrate the model facilitate the parties to actively participate in the process of BIM and ease the process of solving issues within particular projects.

Stepwise multiple regression: Coordination and integration (dependent) with other variables

The multiple regression analysis shows that there is no significant influence to the outcome 'Coordination and integration' by more than one variable simultaneously (see Table 5-30 to Table 5-34).

Table 5-30: Step-1 of stepwise multiple regression for Coordination and Integration

Dependent variable(s)	Independent variable(s)	Adjusted R-squared value	*P value*	*Significance f*	Comments
Coordination and integration	Data exchanges and accessibilities	0.86	0.54310	0.0023 < 0.05	Retained
	Capacity building programme		0.8188		Removed
	BIM implementation plan and protocol		0.1501		Retained
	Value optimisation		0.6283		Retained

Table 5-31: Step-2 of stepwise multiple regression for Coordination and Integration

Dependent variable(s)	Independent variable(s)	Adjusted R-squared value	*P value*	*Significance f*	Comments
Coordination and integration	Data exchanges and accessibilities	0.88	0.5475	0.00043 < 0.05	Removed
	BIM implementation plan and protocol		0.1209		Retained
	Value optimisation		0.3809		Retained

Table 5-32: Step-3 of stepwise multiple regression for Coordination and Integration

Dependent variable(s)	Independent variable(s)	Adjusted R-squared value	*P value*	*Significance f*	Comments
	BIM implementation plan and protocol	0.88	0.1131	0.00007 < 0.05	Removed
	Value optimisation		0.0469		Retained

Table 5-33: step 4 of stepwise multiple regression for Coordination and Integration

Dependent variable(s)	Independent variable(s)	Adjusted R-squared value	*P value*	*Significance f*	Comments
Coordination and integration	BIM implementation plan and protocol	0.88	0.1131 > 0.05	0.00007 < 0.05	Removed
	Value optimisation		0.0469 < 0.05		Retained

Table 5-34: Obtained regression model for coordination and integration in the final step

Dependent variable(s)	Independent variable(s)	Coefficient	Adjusted R-squared value	*P value*	*Significance f*	Comments
Coordination and integration	Intercept	3.19	0.86	0.24456	0.00002 < 0.05	-
	Value optimisation	1.23		0.0003 < 0.05		Accepted

In the multiple regression analysis, it has been found that despite having individual influence of the variable to 'Coordination and integration' in a project, while the variables are on an effect simultaneously, it shows that at least one of the independent variables (i.e. Value optimisation) has an effect on the dependent variable (i.e. Coordination and integration) (see Table 5-34).

In Table 5-34, it is seen that in the model with 'Value optimisation', *adjusted R-squared value* is 0.86, and both *P-value* and *Significance f* are less than the significance level of 0.05. Therefore, the result of the regression analysis proves that there is a linear relationship between 'Coordination and integration' and 'Value optimisation' in BIM enable projects; and 'Coordination and integration' is significantly influenced by 'Value optimisation' within particular projects.

The regression model (rounding coefficients up to two decimal points) is-

Coordination and integration = 3.19 + 1.23 (Value optimisation)*

It is to be mentioned that the derived model similar to the model as shown as in Table 5-29 with the individual influence of the variables which was discussed earlier. In the above model, the coefficient 1.23 (which is closer to 1) states that the level of ‘Coordination and integration’ is influenced by ‘Value optimisation’. Hence, though ‘Coordination and integration’ is influenced individually by number of variables, it has influence of ‘Value optimisation’ in either individual or combined effect with other variables as well. Value optimisation in a BIM project is important to functionalise desired coordination and integration. This is supported by P02-RAR who described, “*From the cultural point of view you can find that, you got the design team involves and working in certain way, the model should be used not the drawings, then you can demonstrate the value of the model and the way through yeah you have got cultural…we have done it*. This statement explains that identifying the areas of adding value and optimising value are performed for the individual parties to functionalise coordination and integration. The statement also describes how the cultural issues are minimised by value proposition to functionalise desired coordination and integration in the project. Also, value optimisation has some direct effects in the project. For example, if a project management identifies that this project will get benefit from 4D time lining or 5D cost inclusion in the building information model, the integration in terms of technology takes place which is passed through the process and carried out by the people.

Simple regression: ‘Interactions between the parties (dependent variable)’ with other independent variables

The results from simple regression analysis are shown in the following Table 5-35:

Table 5-35: Relationship and influence, simple repression for interactions between the parties

Dependent variable(s)	Independent variable(s)	R-squared value	*P value*	*Significance f*	Comments
Interactions between the parties	Data exchanges and accessibilities	0.81	0.00016 < 0.05	0.00016 < 0.05	Accepted
	Capacity building programme	0.40	0.036 < 0.05	0.036 < 0.05	Accepted
	BIM implementation plan and protocol	0.81	0.0001 < 0.05	0.0001 < 0.05	Accepted
	Value optimisation	0.82	0.00007 < 0.05	0.00007 < 0.05	Accepted

The simple regression models of the ‘Coordination and integration’ are shown in the following Table 5-36:

Table 5-36: Simple regression model with influence on interactions between the parties

Dependent variable(s)	Independent variable(s)	Simple regression Model
Interactions between the parties	Data exchanges and accessibilities (DEA)	CAI = 5.0 + 0.94 * (DEA)
Interactions between the parties	Capacity building programme (CBP)	CAI = 7.42 + 0.42 * (CBP)
Interactions between the parties	BIM implementation plan and protocol (BIPP)	CAI = 4.61 + 1.24 * (BIPP)
Interactions between the parties	Value optimisation (VO)	CAI = 4.82+ 0.90 * (VO)

From Table 5-36, it is observed that ‘Interactions between the parties’ is individually influenced by a number of variables, i.e. ‘Data exchanges and accessibilities’, ‘Capacity building programme’, ‘BIM implementation plan and protocol’, and ‘Value optimisation’. From these regression modes, a model is discussed to understand how a variable influences the other one. For instance, among the four models, the model with ‘BIM implementation plan and protocol’ has a highest coefficient of 1.24, and it is closer to 1. This means that under certain conditions, ‘BIM implementation plan and protocol’ influences ‘Interactions between the parties’ more than the other three variables.. This is supported by P01-RSC who mentioned, “*We set up a BIM protocol, how everybody work on file or information, so could all be brought together in a collaborative format, what would we work, what document management system we would use collate that, and how will we view and report against the model which is been developed*”. This shows that the interactive activities within the project delivery process are driven by the ‘BIM implementation plan and protocol’. In contrast, a respondent did not agree with this fact and he mentioned, “*BIM execution plan doesn’t define specifically what they are supposed to be doing*”. This shows that BIM implementation plan does not articulate the interactive behaviour between the parties. This is further supported by the respondent P01-RSK and he asserted, “*So, we set our stall out we have got regular meeting, what we don’t do is set out and detect it how they interact during the development of the model, it is too complicated to apply that interaction you cannot do it in a linear fashion, you need people who light the issues are switched on and who are motivated pick up the phone, tell them the models are ready, you need to work on the detail and take the snapshot*”. This statement describes that the interactions between the parties are prompted by number of factors rather than simply driven by 'BIM implementation plan and protocol'.

Since frequent interactions between the parties in a BIM project indicate that the people share information between each other frequently and collaborate within the modelling process, it is important to functionalise interactions between the parties in a BIM project. This is supported by the respondent P12-RAH who mentioned, "*I think there is a lot of people who collaborating. That's very different when they are working in a federative model. Because, collaboration means, I do my work then pass it across to you in one form or whether it is, in word or whether it is Excel, whether it is an Access database whatever. When you are working in a federative way, people are, they are all working in the same piece of data. And, that's when they think they collaborated, and then they can work in a federative way*". This statement explains that collaboration in a BIM project is driven by exchanging information which is also connected to the 'Data exchanges and accessibilities' (see the 1st model in Table 5-36). Thus, interactions between the parties are individually influenced by a number of variables in a project and it is an important part of the project outcomes to ensure collaboration in a construction project.

Stepwise multiple regression: 'Interactions between the parties (dependent variable)' with other independent variables

To observe the combined effect of the variables on the 'Interactions between the parties', multiple regression analysis has been performed. It has been found that this outcome is influenced by at least one variable, i.e. 'Value level of BIM'. The results are shown below (see Table 5-37 to Table 5-39):

Table 5-37: Step-1- Interactions between the parties

Dependent variable(s)	Independent variable(s)	Adjusted R-squared value	*P value*	*Significance f*	Comments
Interactions between the parties	Data exchanges and accessibilities	0.90	0.59	0.00014 < 0.05	Removed
	Capacity building programme		0.39		Retained
	BIM implementation plan and protocol		0.136		Retained
	Value optimisation		0.34		Retained

Table 5-38: Step-2 - Interactions between the parties

Dependent variable(s)	Independent variable(s)	Adjusted R-squared value	*P value*	*Significance f*	Comments
Interactions between the parties	Capacity building programme	0.89	0.132	0.0002< 0.05	Removed
	BIM implementation plan and protocol		0.129		Retained
	Value optimisation		0.018		Retained

Table 5-39: Step-3 Obtained multiple regression result for 'Interactions between the parties' in the pre-final step

Dependent variable(s)	Independent variable(s)	Adjusted R-squared value	*P value*	*Significance f*	Comments
Interactions between the parties	BIM implementation plan and protocol (BIPP)	0.86	0.084 > 0.05	0.0014< 0.05	Removed
	Value optimisation (VO)	0.78	0.047 < 0.05		Accepted

In the multiple regression analysis (see Table 5-39), it has been found that while the variables are on effect together, the result proves that at least one of the independent variables (i.e. Value optimisation) has an effect on the dependent variable (i.e. Interactions between the parties).

From Table 5-35, 5-36, and 5-39, it has been observed that in the model with 'Value optimisation', *adjusted R-squared* value is 0.90, and both *P-value* and *Significance f* are less than the significance level of 0.05. Therefore, the result of the regression analysis shows that there is a linear relationship between 'Interactions between the parties' and 'Value optimisation' in BIM enable projects; and 'Interactions between the parties' is significantly influenced by 'Value optimisation'.

The regression model (rounding coefficients up to two decimal points) is-

*Interactions between the parties = 4.8 + 0.90 * (Value optimisation)*

The derived model is similar to the model shown in Table 5-36 with the individual influence of the variables. In the above regression model, the coefficient 0.90 (which is closer to 1) states that the level of 'Interactions between the parties' is influenced by 'Value optimisation'. Hence, although 'Interactions between the parties' is influenced individually by number of variables, it has influence of 'Value optimisation' in either individual or combined effect with other variables (see Table 5-35 and 5-36). Therefore, value proposition in a BIM project is important to functionalise frequent interactions between the parties in the project. For example, a project management decides that the project will be controlled zone basis. In that case, beside the interactions take place with respect to the whole project, interactions between the parties involved with the particular zone are functionalised. These interactions in turn help them to remove the hazards and get the clearance for work in a particular zone where no delay or conflict will be occurred. Thus, interactions also take place while people intend to use the model for clash detections or integrate various dimensions such as 4D time lining or 5D cost. As such, intention of using the model at more extensive level (value proposition) fosters the interactions between the parties, which in turn bring some benefits in the project. This kind of frequent interactions enhances clarity of various works in a project and saves time.

Summary of regression analysis and correlation test

Figure 5-5 has been drawn according to the relationships and influence found in correlation test, and both simple and multiple regression analyses between the variables, which support the findings in the GT study. The blue dotted lines show the influence of individual variable(s) to the other dependent variable(s). The black lines show the relationship and influence identified in the multiple regression analyses. This is to be mentioned here that if a category

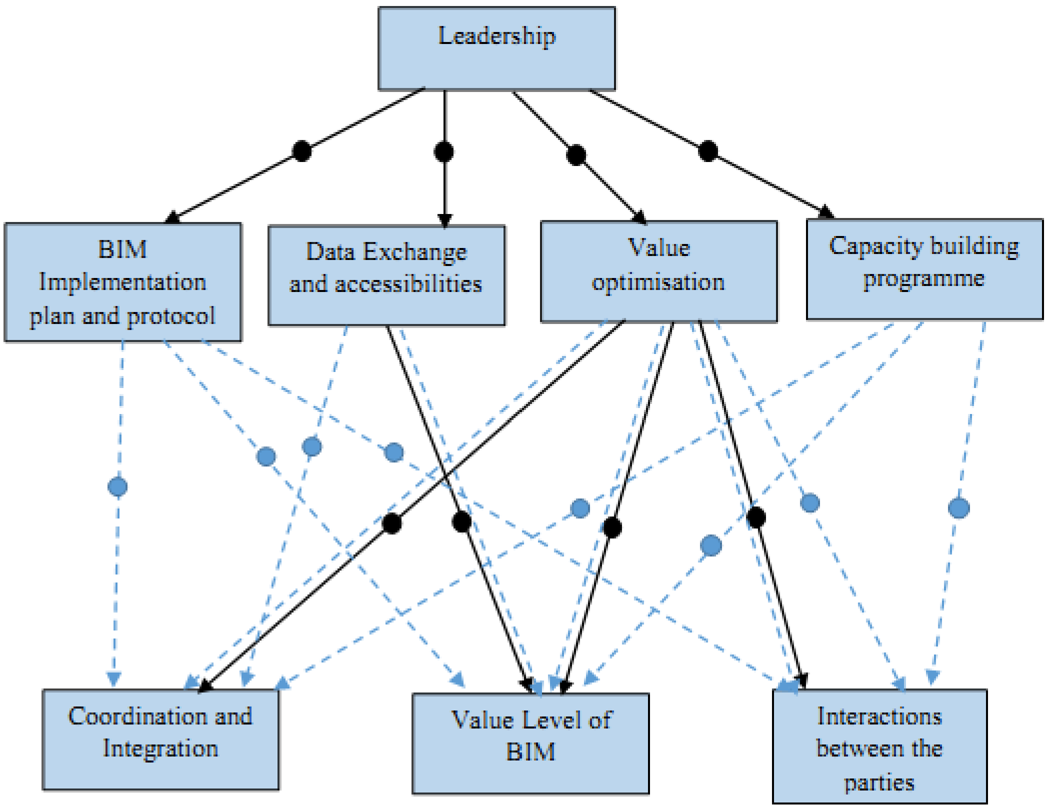

Figure 5-4: Relationships and influence within the parts of BIM and outcomes of the implementation of BIM

has influence on one or more categories, or, a category is influenced by one or more categories, relationships exist between them (see Figure 5-4).

In Figure 5-4, this can be seen that leadership is at the top of the diagram. This is at the top because the project leader is a person who designs and undertake necessary activities the implementation of BIM. Therefore, leadership is an influential factor to other factors those are at the middle. As the coordination and integration, value level of BIM and interactions between the parties are the consequence of various elements such as implementation plan and protocol, data exchanges and accessibilities, value proposition, and capacity building programmes' the ultimate outcomes in a BIM project are placed at the bottom of the diagram.

The relationships identified in the study confirm that the leadership in a BIM project is a significant part of the implementation of BIM. The leadership influences the different elements of the implementation of BIM. These are: the articulated BIM implementation plan and protocol, the system of data exchanges and accessibilities, identification of the value to be added through different activities of BIM, and capacity building programmes to support the adoption of BIM within the project delivery process in particular projects. These are the internal factors which dominate the outcomes of the implantation of BIM i.e. collaboration through coordination and integration, and interactions between the parties, and adding extra value throughout the whole lifecycle of the project. In the Figure 5-4, it is observed that 'Value optimization' has influence on all the three outcomes with multiple regressions. This means that identifying value for individual parties in a project including the client is one of the critical factors to implement BIM successfully in a construction project.

5.4 Indication from GT Study in Terms of Culture of the PBOs

The results found in the GT study explained the previous sections in this chapter indicate that the implementation of drives the culture in the PBOs. To attest this indication further investigation has been performed by CVF analysis and discussed with the findings in the GT study, which is discussed in the following section.

5.5 Development of Culture in the PBOs and Results from CVF Analysis

Identification of culture of the projects is attempted by both GT study and CVF analysis. Cultures of individual organisations have been identified from the notions of GT study. Based on the expressions and provided information by the respondent through the semi-structured interviews, cultures of various PBOs became apparent. To clarify the findings in terms of culture in the GT study, independent CVF analyses for various projects have been performed.

CVF analysis is also used to understand the influence of the cultures carried by individual organisations involved particular projects. To clarify the cultural influence of the individual organisations in BIM-enabled construction projects, CVF analysis has been performed for both BIM and non BIM projects. The CVF analysis has not been performed for all the investigated projects due to a number of reasons. For instance, a project might be excluded due to either lack of sufficient data or presence of inconsistent data. The received scores of CVF for the cultures of individual projects are sown in the tables below (see Table 5-40 and 5-41):

Table 5-40: Received CVF scores in BIM projects

Project	Project outcomes	Project culture	Culture/Value				
			Cultural stance	Lead contractor	Subcontractor	Consultant A	Consultant S
P01-HW	VLB: 16 COI:20 INT:16	29.67	Clan	20.28	31.67	-	-
		12.33	Adhocracy	33.06	17.92	-	-
		24.0	Market	21.94	20.42	-	-
		34	Hierarchy	24.72	26.67	-	-
P02-HA	VLB:16 COI:17 INT:16	40	Clan	20.00	51.67	56.67	20.83
		21.25	Adhocracy	33.33	21.67	11.67	15.83
		26.46	Market	28.33	15.00	13.33	25.00
		37.29	Hierarchy	18.3	11.67	18.33	38.33
P03-FA	VLB:5 COI:9 INT:10	21.67	Clan	27.5	-	-	-
		36.67	Adhocracy	34.16	-	-	-
		22.5	Market	14.16	-	-	-
		19.17	Hierarchy	22.5	-	-	-
P06-WS	VLB:9 COI:17 INT:15	39.16	Clan	-	-	-	23.33
		18.33	Adhocracy	-	-	-	19.67
		13.33	Market	-	-	-	33.33
		29.16	Hierarchy	-	-	-	23.33
P07-TH	VLB:4 COI:6 INT:7	60	Clan	61.67	-	-	-
		21.67	Adhocracy	20.00	-	-	-
		10	Market	10.83	-	-	-
		8.33	Hierarchy	7.5	-	-	-
P08-DM	VLB:6 COI:12 INT:10	31.67	Clan	58.33	-	-	-
		19.67	Adhocracy	16.67	-	-	-
		31.67	Market	14.17	-	-	-
		15.83	Hierarchy	10.83	-	-	-
P09-SA	VLB:8 COI:11 INT:11	22.92	Clan	16.25	-	-	-
		19.58	Adhocracy	11.25	-	-	-
		31.67	Market	33.75	-	-	-
		25.83	Hierarchy	38.75	-	-	-
P11-SF	VLB:6 COI:10 INT:9	21.67	Clan	26.67	-	-	-
		21.67	Adhocracy	18.33	-	-	-
		30	Market	26.67	-	-	-
		26.67	Hierarchy	31.67	-	-	-

VLB: Value level of BIM

COI: Coordination and Integration

INT: Interactions between the parties

These are the overall outcomes of the projects.

Table 5-41: Received CVF scores in Non-BIM projects

Project	Project culture	Culture/Value		
		Cultural stance	Lead Organisation	
Non-BIM-1	32.5	Clan	36.67	Lead organisation is a contractor
	30.83	Adhocracy	31.67	
	23.33	Market	18.33	
	13.33	Hierarchy	13.33	
Non-BIM-2	43.33	Clan	41.67	Lead organisation is a client
	4.1.7	Adhocracy	5.83	
	5.00	Market	4.17	
	47.5	Hierarchy	48.33	

From the data shown in Table 5-40 and Table 5-41, plotting and discussion are made on the individual projects described below:

Project P01-HW

In this project people were found simply following the instructions coming from the project leader or top management. This is supported by a number of respondent in the project. For example, a respondent P01-RKT mentioned, "*There are strict guidelines that we got to achieve the end result*". This statement describes that the people within the project are structured and rule-driven. This is further supported by another participant P01-RPH who mentioned, "*Yes, very much (controlled). They make it that obviously through a management structure, also the quality to see that we are in place*". The controlled and structured attributes of the project indicate the hierarchy dominating culture within the project. However, this project also have considerable collaborative attribute. For instance, a respondent P01-RSC responded, "*We are all working collaborate to pull the model, we sit together for clash detection meeting, we are all driving towards final solution*". The expression of the respondent shows the notable presence of collaboration within the project supply chain. Hence, the clan culture is also present in the project.

According to the CVF analysis for this project, the composite culture of this project is dominated by hierarchy culture and the second dominating culture is clan culture whereas the dominating culture of the lead contractor and a subcontractor are adhocracy and clan respectively (see Figure 5-5). The second dominating culture of both involved organisations is hierarchy culture which is also the composite culture of the PBO itself. In this project, it is seen that the PBO does not hold none of the dominating cultures of the involved organisations. The project outcomes are high in this PBO with a hierarchy culture. This observation reveals that the culture of this PBO is not driven by the culture of any of the involved organisations.

	Organisation	A	B	C	D
	CVF Project P01-HW	29.667	12.33	24	34
	Lead contractor	20.77	30.056	21.94	24.72
	Subcontractor	31.67	17.92	20.41	26.67

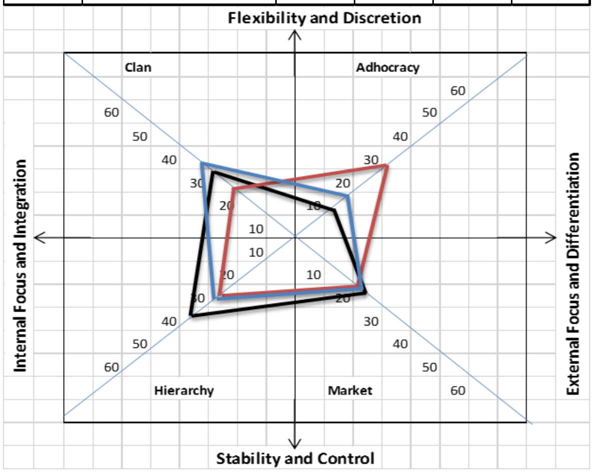

Figure 5-5: Various cultures in project P01-HW

	Orgnaisation	A	B	C	D
	CVF Subcontractor M&E	51.67	21.67	15	11.67
	CVF Consultant S	20.83	15.83	25	38.33
	CVF Lead contractor	20	33.33	28.33	18.33
	CVF Consultant A	56.67	11.67	13.33	18.33
	CVF Project	40	21.25	26.45	37.29

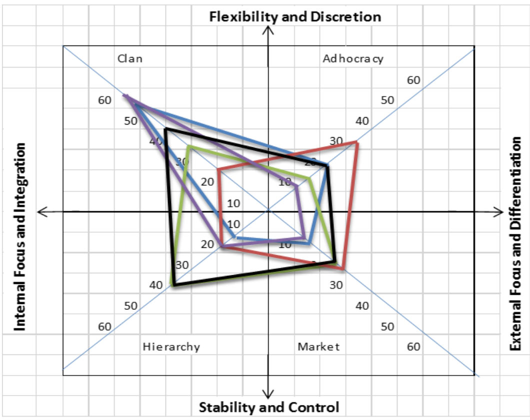

Figure 5-6: Various cultures in project P02-HA

P02-HA

In this project, the culture is developed found as much more collaborative that the other types of cultures. This developed culture can be recognised from the response by the respondent P02-RGC, “*There is a kind of hierarchy of leaders below me is very collaborative. And, all those people probably 60 or 70 in the hierarchy on this project. This is not a sort of stress*”. This statement indicates that the working level of the project is very much collaborative whereas having the significant presence of the hierarchy culture to a certain extent. This statement also follows the findings in the CVF results for this project.

From the results of the CVF analysis on the projects P01-HW and P02-HA, the dominating culture of the lead contractor is adhocracy culture. A subcontractor holds clan culture, and two consultant organisations hold clan and hierarchy culture respectively (see Figure 5-6). It can be observed that the consultant A and the subcontractor have higher value of clan culture which is the dominating culture of the PBO and the second dominating culture of the PBO is hierarchy. Here, the PBO is not dominated by the lead organisation. The project outcomes are high with a clan culture in this project. The cultural stances of both PBO and various parent organisations indicate that a PBO is not dominated by any particular organisation involved in a BIM project. Based on the observations on projects P01-HW and P02-HA, it is revealed that culture in a BIM-enabled PBO dominated by the implementation of BIM, not by any particular organisation involved with the project. The overall outcomes of BIM are higher in both projects. These two facts indicate the extensive level of the implementation of BIM leads the culture of these projects.

In Table 5-40, it can be observed that the dominating culture of the parent organisation for both projects P01-HW and P02-HA is Adhocracy and scores of this culture in these projects are very close i.e. 33.06 and 33.33 respectively. This is to be mentioned here that these two projects are leaded by the same main contractor but the locations of projects are at different corners of the state. There is a rare chance of having interactions between participants of these two projects. The respondents filled the OCAI questionnaire individually. However, the scores of individual projects are nearly same. This indicates that the determination of culture through CVF for organisations reflects the existing picture of the culture.

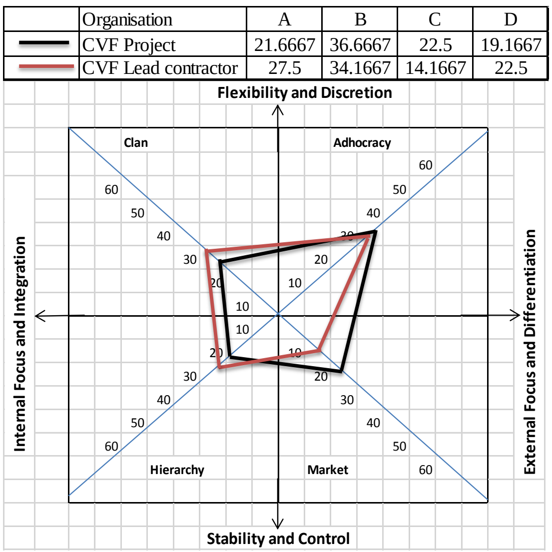

Figure 5-7: Cultures in the project P03-FA

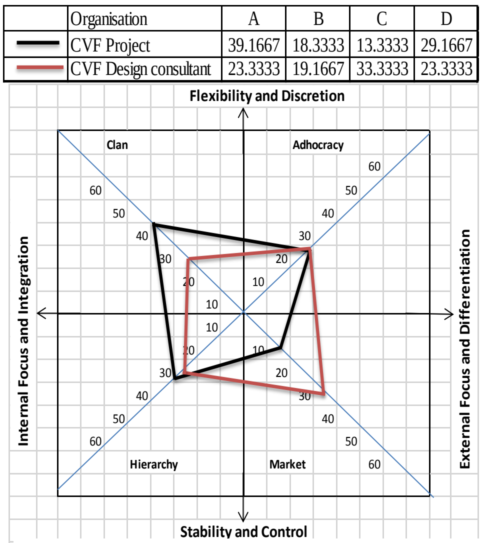

Figure 5-8: Cultures in the project P06-WS

P03-FA

This project is adopting new technology and a lot of innovations are taking pace. For example, the respondent P03-RNW mentioned that the project was adopting an innovative method and he commented, "*…in innovative method is remove or some change, apply that. And that's the theory I am taking to that particular way*". This statement shows the presence of innovation which is also can be seen from another expression, "*I think what us set in model, the virtual 3D model which for production, for coordination and communication, and that is you can go down the Rivet click on the Asset, and it will take you to all the information to the building through the system. It is a bit like Google maps. It also collaborating GIS*". The presence of various activities including GIS is obviously the indication of innovation through the implementation of BIM. This is further clarified by the words "*I am taking to that particular way*" from the first statement. The dominating culture of the PBO adhocracy is also supported by the following findings form the CVF analysis:

With project outcomes of a medium range, the dominating culture of this PBO is adhocracy culture which is similar to the culture of the main lead contractor organisation (see Figure 5-7). Here, the PBO culture is dominated by the lead organisation where the overall outcomes of BIM are not very high. This also indicates that as BIM is not implemented in this project at an extensive level, the culture of the PBO is still dominated by the lead contractor.

P06-WS

People in this project are more focused on collaboration. This project is coordinated among the organisations which are residing in different countries. A lot of coordinations are taking place in this project which can be seen from the overall outcomes; especially, the value of collaboration of 17. The respondents in the project P06-RAC mentioned, "*There are two types of coordinations. One is internal within B&V various offices it is internal. In Mumbai there are some people working in Castle city in the state. There are some people working in the …in Chile, and also on site. We are at the middle in the UK. So, that's the internal coordination we do within the company and that's the common platform. So, anyone using whether in Mumbai or site they know exactly what the project structure is, and where to find the information. So, there is a tool, collaborative tool available where to find all the information everything is stored there. So, that's the internal side of it; but also externally we use BIM for suppliers*".

This statement shows that the collaboration is taking place in these types of projects from various ways. This is further supported by the respondent P06-RDM who mentioned, "*We are using the Line software, it is very easy for the people to talk to one another and you can see the people are online, you can share screens with the people, it is just how you do communicate…in different time zones and different countries people based around different corners in the world. I think just effectively we can contact people and share information as well. It makes the process manageable*". This statement also indicates the strong presence of collaborative culture among the participants with the project. Hence, the culture within this project exhibits is clan culture. Following is the cultural assessment from CVF analysis for this project:

The dominating culture this PBO is clan culture whereas the dominating culture of the main design consultant is market (competition) culture (see Figure 5-8). The overall outcomes of BIM are upper medium. This project is mainly lead by the client. The culture of client is unknown in this study. The dominated PBO culture is congruent with the culture of lead design consultant in this project. This indicates that the culture of the PBO is driven by the overall design coordination process which is reinforced by the implementation of BIM.

	Organisation	A	B	C	D
	CVF Project	60	21.6667	10	8.33333
	CVF Lead contractor	61.6667	20	10.8333	7.5

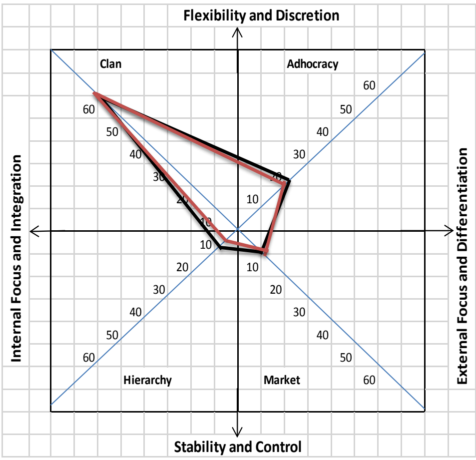

Figure 5-9: Cultures in the project P07-TH

	Organisation	A	B	C	D
	CVF Project	31.6667	19.1667	31.6667	15.8333
	CVF Lead contractor	58.3333	16.6667	14.1667	10.8333

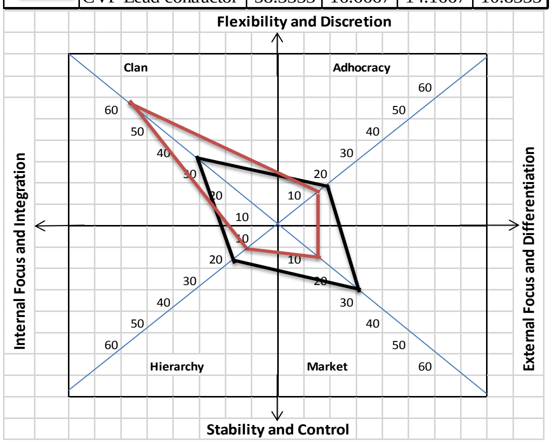

Figure 5-10: Cultures in the project P08-DM

P07-TH

The size of the PBO in this smaller and they work as a single team. The respondent in this project mentioned, "*On the way we count the strategy we will see MEP and we are the architect in the same building. That's how we collaborate between two companies that are on-going with the company. And the other consultant is FTP site collaboration. With the other like structural we collaborate with FTP*". This statement illustrates the well presence of collaboration within the project team. Collaboration and interactions are present in this project though the overall outcome is not very high. This means that collaboration is taking palace but not fully operative by BIM. This is further supported by the respondent when he mentioned, "Definitely there is room for improvement". The culture is assessed by CVF which is discussed below:

With lower overall project outcomes, the dominating culture of this project is clan culture which is similar to the dominating culture of the main contractor (see Figure 5-9). This is a small organisation and all participants are working for the same company except one supplier. Implementation of BIM in this project is at a poor level. The close sores of the lead contractor and PBO clarifies the reason behind the dominated project culture, i.e. the PBO culture is strongly dominated by the lead organisation as there is also no reasonable chance to bring a culture by any other organisations.

P08-DM

This project is a UK BIM-enabled project where implementation of BIM has a positive impact on the delivery process, which has been found through the investigation. People on this project coordinate from different offices. In this project, a sound level of collaboration and interactions are happening among the participants that can be seen from the values of coordination and integration and interactions (see Table 5.40). The phenomenon is supported by the expression of the respondent P08-RJH who mentioned, "*I am working based in London. So, I do a lot of work on Revit cluster server, with the guys in Glasgow, because I can't be up there all the time. So that's how do we work internally across service; and in a large scale of…there is a lot of communications, a family you got to keep the communication channels very open*". This statement describes a notable phenomenon of collaboration which indicates the clan culture of the project. The respondent further mentioned, "*We are result driven, obviously we are collaborative, we specify without concerns how to work in Revit, then we mark it from handling* *your databases for market session, but we do also a bit foster the environment we can collaborate, and work at site level, and produce the best job we can. But we also think about that we have to do internally ourselves and we follow a certain process to make sure that we hit our goals*". This statement clearly shows two pictures, one is the PBO is result driven that indicates a market culture; the other picture is the presence of collaboration that indicates clan culture of the PBOs. These two cultures are dominating in this project. The other types of culture might be present but not significantly developed as found in the study. The culture of this project is also assessed by independent CVF analysis to justify the dominating culture in the project.

According to the score of CVF analysis, culture of this PBO is dominated by two equally valued culture, i.e. clan and market culture. The dominating culture of the main contractor is clan culture and the value of market culture of this organisation is too low to dominate the project culture (see Figure 5-10). Hence, market culture in this project might be brought by some other organisation(s) involved in the project. The overall outcomes of BIM are of a medium range. A medium level of implementation of BIM and the cultural stances of PBO and lead organisation indicate that the culture is being either brought by another organisation or developed by the implementation of BIM. Hence the results from CVF analysis support the findings in the GT study.

	Organisation	A	B	C	D
	CVF Project	22.9167	19.5833	31.6667	25.8333
	CVF Lead contractor	16.25	11.25	33.75	38.75

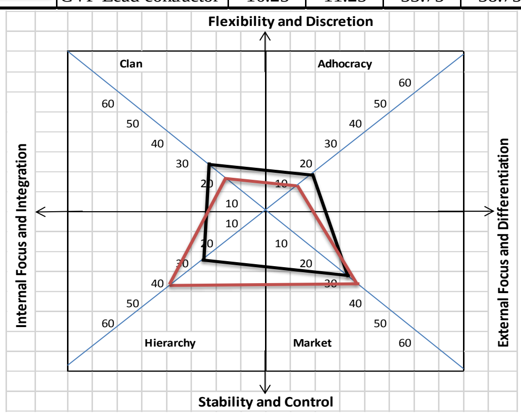

Figure 5-11: Cultures in the project P09-SA

	Organisation	A	B	C	D
	CVF Project	21.6667	21.6667	30	26.6667
	CVF Lead contractor	26.6667	18.3333	26.6667	31.6667

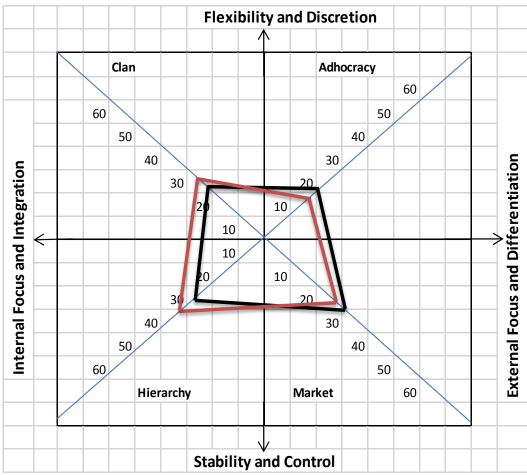

Figure 5-12: Cultures in the project P11-SF

P09-SA

From the investigation through GT study, this project has been found as competitive and structured. As a very old and experienced lead organisation, organisational structure and competition between the parties are focused in the PBO. This phenomenon becomes apparent from the statement of the participants in the project. One of the respondents P09-RAG in this project mentioned, "*There is lot of completion, also a lot of blame between subcontractors, like 'you haven't done this', and 'you have stopped me from that'*". This statement shows that there is competition between the parties which indicates market culture in the project. Another respondent P09-RSH mentioned, *"The lead contractor is quite as an organisation structured*". This shows that the culture of the project is also driven by the intention of the lead contractor how they want to work in the project while BIM is on board. Thus both market and hierarchy culture is apparent in this project.

According to CVF analysis, this PBO is dominated by market culture with upper-mid range of overall outcomes of BIM (see Figure 5-11). However, the culture of the lead organisation is dominated by hierarchy culture. In this project the major dominating culture is market culture and second dominating culture is hierarchy culture. This picture is congruent with the findings form the GT study.

P11-SF

This is a project where implementation of BIM is fully designed earlier. For instance, the implementation plan and value proposition are articulated prior to submission of bid documents in this project. According to the project leader, the major focuses of implementing BIM are to collaborate for best and competitive project delivery As such, a competition is clearly visible in this project and this indicates the market culture of the project. The respondent P11-RSF mentioned, "*We have a lot of competition in terms of delivering the quality*". This statement illustrates the competition nature of the PBO for delivering the project through collaboration. The respondent further mentioned, "*It is totally teamwork*". This statement shows that clan culture is notably present in this project.

According to CVF, the dominating culture of this PBO is market culture and the culture of the lead organisation is dominated by hierarchy culture (see Figure 5-12). The overall outcomes of

BIM are of an upper-mid range. The cultural stances of both PBO and the lead organisation and the extent of BIM indicate that BIM has an influence on the culture of the PBO to an extent in this project. However, the findings in the CVF do not support fully the findings in the GT study, it supports partially. For example, the strong dominating culture is found as market and clan cultures in the GT study but CVF shows the market and hierarchy cultures in this project.

	Organisation	A	B	C	D
	CVF Project	32.5	30.8333	23.3333	13.3333
	CVF Lead contractor	36.6667	31.6667	18.3333	13.3333

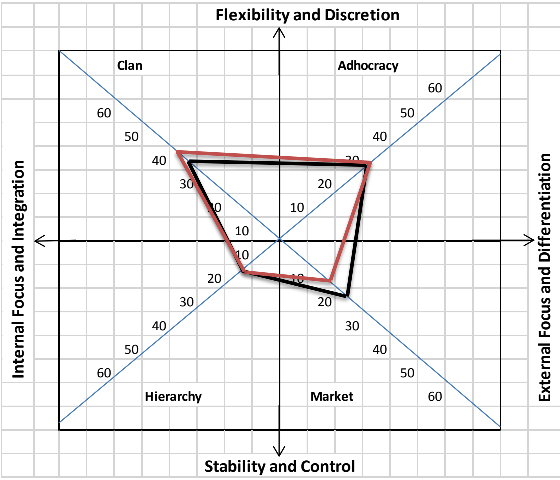

Figure 5-13 Cultures in the Non-BIM project-1

	Organisation	A	B	C	D
	CVF Project	43.3333	4.16667	5	47.5
	CVF Lead contractor	41.6667	5.83333	4.16667	48.3333

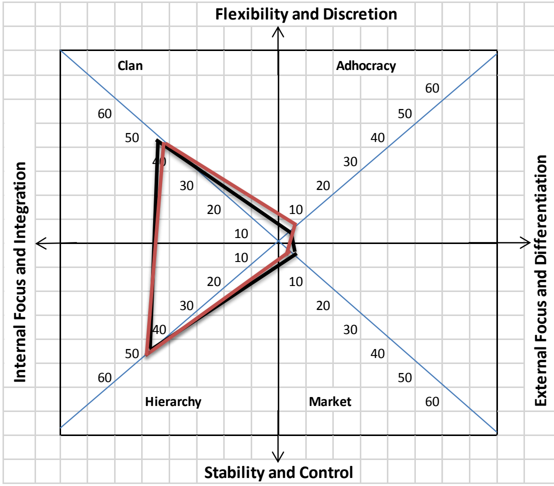

Figure 5-14: Cultures in the Non-BIM project-2

Non-BIM Project-1 and Non-BIM project-2

Cultures of project-based organisations are highly influenced by the culture of the lead organisations. The dominating culture in the Non-BIM project-1 is clan culture and that in the Non-BIM project-2 is Hierarchy culture (see Figure 5-14 and Figure 5-15).

Summary of Cultural Assessment in the PBOs

From the above discussions, it can be perceived that there is no particular culture that dominates the BIM-enabled projects. In addition to this it can be comprehended that there is no significant tendency of the lead organisations to dominate the culture of the relevant projects. A project can score any level of the outcomes of BIM with any type of culture. By taking these facts together into an account it is established that in a BIM project, the culture of the PBO is not necessarily dominated by the lead organisations or any other organisations involved with the project. For example, in project P02-HA, the project culture is similar to the dominating culture of the subcontractor (M&E) and the architectural consultant, not by the lead organisation. Culture of the PBO is constructed by the organisational vision of the lead organisation for this particular project. However, the culture in project P0-HA is dominated by neither the lead organisation nor the subcontractor. Although the culture of parent organisation receive scores closer in projects P01-HW and P02-HA, the culture of PBOs in these projects are different. Both projects have higher level of success. This means, there is no particular culture that makes the implementation of BIM successful in a project. Projects Non-BIM-1 and Non-BIM-2 are dominated by different cultures but both of them are dominated by the lead organisations.

Based on the overall discussion in CVF analysis, it has been established that implementation of BIM in a PBO builds the culture that is underpinned by its process. This is supported by a number of respondents. For instance, the respondent P01-RAF described the change of culture through BIM as "*Certainly there is a big cultural change of age*". This shows that implementation of BIM has impact on the culture of PBOs and enables changes in the long-term culture within the construction projects. The change is not only driven by the enforcement of certain process but also the foreseeable benefits for all the parties. This is supported by the respondent P01-RPH who mentioned, "*It is very very different. We are able to meet and beat programme each; and we have delivered a safer environment for our operators installing. We have less risks, and we are able to reduce the programme (meant length of the project duration), so that the implementation of BIM has been massive (impact) on this project*. This shows the impact of BIM in the project is significant which also includes rethinking the programme or procedure of execution.

Notable Evidences

All the four kinds of culture have been found in PBOs across the investigated projects. In projects P02-HA, P06-WS and P07-TH, all these three are dominated by clan culture but the overall outcomes are different. With a similar dominating culture in the PBOs there are significant variations on overall outcomes of BIM, i.e. the success of the implementation of BIM.

In projects P01-HW and P02-HA, the overall outcomes are very close to each other but the dominating cultures in the PBOs are hierarchy and adhocracy respectively.

Projects P09-SA and P11-SF are dominated by Market culture and the overall outcomes are quite closer but differ from each other.

Project P08-DM shows exceptional feature in terms of dominating culture. In this project, both clan and market culture have been found with equal CVF score. This means that both cultures dominate this project.

Project P03-FA has adhocracy culture with medium range of the overall outcomes of BIM. According to adhocracy culture, there is a great deal of collaboration within the project but the success level is not significantly high.

Based on the above discussions and notable evidences, following three facts have been revealed-

- The composite culture of a PBO is constructed through the implementation of BIM, not dominated by the particular organisations involved in the project, and
- The success of the implementation of BIM is not driven by the any particular culture adopted a project.
- The implementation of BIM does not develop any particular type of culture in the projects.

The overall findings in the study are summarised in the next Chapter 6.

CHAPTER 6: SUMMARY OF THE STUDY

This research has been carried out by following diverse methodologies. Both qualitative and quantitative methodologies have been applied through triangulations in the investigation. The triangulations include Grounded Theory (GT) study, Correlation test and regression analysis, and Competing Values Framework (CVF) analysis. Findings were discussed separately. The linkages between the findings in different methodologies have been identified to clarify the notions and evolved substantial theories. All these activities are summarised and the research objectives have been met as discussed in the following sections.

6.1 Findings Meet the Objectives of the Research

The following discussions are made by combining the findings to identify the facts in terms of the objectives of the research:

6.1.1 The Relationship between the Elements of Culture and the Implementation of BIM in the Project-Based Organisations

Culture in a BIM-enabled project is seen in various aspects while BIM is in operation. These are:

Leadership in BIM project is an important element of culture and has influence on the culture in the BIM-enabled project-based organisation. Level of understanding on BIM, controlling power, and actions of a leader drive the project team through the various activities of BIM.

According to IPD principle, leadership is delegated to the most capable person. However, in a BIM-enabled project, the project leader needs to understand the new process at the top of having experience in project delivery. Once a project leader understands the optimal capacity of BIM that will be purposeful for a particular project, and it is possible for the person to get involved with the whole supply chain and to lead the project. In this research, a project leader is defined as the identifiable person who designs the implementation of BIM for delivering the project and gets involved with the whole supply value chain. Leadership with such characteristics regardless the styles of leadership can drive the successful implementation of BIM with influencing the culture in the projects. The influence of culture is caused through the involvement of the project leader with the substantial elements of BIM. These are the 'Data exchanges and accessibilities', 'BIM implementation plan and protocol', 'Value planning', and 'Capacity building programmes'. From this multi-method study, it has been identified that these four elements regulate the outcomes in a BIM project.

Data exchanges and accessibilities, and BIM implementation plan and protocol develop the collaborative working environment and act as organisational glue to hold the participants together towards a common goal. This also enhances the loyalty and mutual trust among the particulates. For example, access of the client in the information model enhances the mutual trust between the client and the project team and this encourages the long term relationship between them. Open data environment and open access for the parties facilitates smooth operation of the PBOs and minimises waiting time for information for the interdependent parties. These features of the project delivery process come from the strategic emphasis on the information control in a BIM project.

Value optimisation is one of the key drives of a successful BIM enabled project. This also motivates and drives the participants towards the objectives of the project team. To realise the value in accordance with the planning for a particular project, necessary skills are harnessed and gaps are filled by capacity building programmes. Technical barriers in a BIM projects can be addressed by the capacity building programmes in line with the value proposition for a particular project. Additionally, it has been found that an achievable value planning that embraces everybody's interest motivates the people from various organisations in a project to participate in collaboration.

The outcomes **coordination, integration, and interactions** in a BIM-enabled project reflect the various features of the PBOs such as dominant characteristics or management of the employees. In a word, these outcomes play a vital role to build the culture in the project. For instance, a project with open data accessibilities and highly collaborative working way indicate the clan culture in the project. In contrast, a highly structured and rule-driven BIM-enabled project may have collaboration (clan culture) whereas if the management focuses on end result, market culture may be developed in the project-based organisation.

The activities participated by the respondents within coordination, integration, and interactions represent the collaborative working in a construction project. The activities such as working in a common data environment, communication through the model, integration of time line or costs, discussions made on annotations, data exchanges though the models, offsite coordinations, and coordination for particular zone fulfil the principle 'collaborative design and construction' and the major parts of BIM i.e. 'data rich technology' and 'integrated design and construction'. In a word, the collaborative project delivery process which is the major intention of the collaborative arrangements (IPD, BIM, and IPI) is achieved through the implementation of BIM. In such an environment, it was found that adversarial culture is discouraged among the participants.

The level of BIM that is presented in this research by the **value level of BIM** is a part of outcome that is at the ultimate desire of the project team. The value level of BIM informs the participants what they are achieving from the implementation of BIM. Indeed, a better value level must be achieved through a number of activities which also drives the development of culture in the project. For example, if the parties can avoid all clashes and waiting time for sharing information, that means the parties have participated in clash detections and, produced information in a certain format, and shared through a common repository. Also, interactions between the various functional parties have taken place within the particular project.

These factors (or elements) discussed above are the factors which have been identified by GT study in the BIM projects. The findings also show that these are interrelated and drive the culture in a BIM-enabled project. The correlation test and regression analysis also support the relationship between the culture of PBOs and the implementation of BIM. The relationships between the elements are reinforced by the results from the CVF analysis which show that the culture in a BIM-enable project is driven by the implementation of BIM. Also, the implementation of BIM does not develop any particular culture, or, no particular culture dominates the success of the implementation of BIM.

6.1.2 Current Cultures in BIM-Enabled Projects

There are various cultures found in the investigated BIM-enabled projects. Through the GT study and CVF analysis, the four cultures, i.e. clan, adhocracy, market, and hierarchy have been identified across the projects. It has been also established that a project may have more than one cultures dominating equally. For example, in P01-HW, the dominating culture of the PBO is hierarchy whereas second dominating culture is clan, and the culture in P02-HA is clan culture whereas the culture in project P08-DM has been identified as two equally dominating types, i.e. market and clan cultures. Therefore, though today's vocabulary on BIM expresses the collaborative culture, the clan culture is not necessarily the primary dominating culture in the projects. It is to be mentioned here that the presence of culture has been found at an upper level in the case of the projects with other dominating cultures. Therefore, collaboration is a vital attribute of BIM-enabled projects.

6.1.3 Success of the Implementation of BIM

Success of the implementation of BIM is seen in various aspects. For example, in the UK, some of the people simply percept the success on the level of BIM they are adopting and some are focused on the achievement according to the value proposition of BIM. However, some of the PBOs highlight the acceptance of BIM to the parties as the success of the implementation of BIM rather than commercial success. For example, in P09-SA project, it has been found that when people learn the process of BIM form the first implementation of BIM in a project, they do not want to go back to the traditional project delivery process any more. For this research, success was measured in terms of outcomes such has the level of collaboration (coordination, integration and interaction between the parties) and the value level of BIM. The outcomes across the investigated projects are found notably varied. The various methods of interpreting data such as GT study, correlation test, and regression analysis show that the variations of outcomes are linked with the elements of BIM (BIM implementation plan and protocol, data exchanges and accessibilities, value proposition, and capacity building programmes). These elements of BIM control the outcomes and culture in the BIM-enabled projects. It has also been found that association of leadership in a BIM-enabled project is related to both the elements of BIM and the culture of the particular projects.

6.1.4 Impact of the Implementation of BIM in the Culture of the Construction Projects

The implementation of BIM has notable impact that builds and holds the culture of BIM enabled projects. It changes the way of working. For instance, there are a number of activities performed in BIM-enabled projects. Accordingly, there are few activities and attributes of traditional projects those are removed by the implementation of BIM. By attaining a technology-driven project delivery process where information is shared through a common repository and effective coordinations are performed, the major burdens of traditional project delivery process, i.e. process fragmentation and adversarial culture are eliminated. In fact, the implementation of BIM-changes the way of working and daily vocabulary of construction projects which are discussed earlier.

6.1.5 The Relationship between the Individuals' Company Culture and Project Culture in BIM Projects

The results of this study show that in BIM enabled projects, there is no significant relationship found between the culture of the involved parent organisations and the PBOs. A parent organisation such as contractor, designer, architect or whoever may have a particular type of culture but that culture will not necessarily dominate the culture of the PBO. The culture of the PBO is driven by the implementation of BIM.

6.2 Credibility and Contribution to the Knowledge from the Research

This research has credibility on novel findings and contribution to the knowledge. The following are the credibility and contribution to the knowledge from which the industry and academia will be benefited:

- The literature review gives a salient feature of collaborative working arrangements such as IPD and BIM, and the current relevant issues which the industry need to address to get the desired value through the implementation of BIM. For example, suitable leadership, realistic measures for motivation, integrated teamwork and several barriers to these elements which need to be considered during the implementation of modern technology.

- In this research, the phenomena of BIM-enabled projects have been constructed according to various levels of BIM. This gives a clear understanding on the significance of various elements of BIM to the outcomes in the projects. For example, the elements of BIM which capture various activities underpinned by technology are interlinked, and influence the outcomes, i.e. collaboration and projects values. Each of the elements such as leadership, implementation plan, and value planning or data exchanges accessibilities has distinct level of influence to the outcomes. These values will help the individual projects designing the implementation of BIM. Findings from this research can also be used to identify the desired feature and impact of the implementation of BIM at various capacities. All these findings in the BIM-enabled projects will contribute to new stock of knowledge.
- The desired activities of the project leaders and other participants are identified from various projects of different levels of BIM. Desired values in a BIM project is articulated through the investigation. The activities and values articulated will give a sense of the success of a BIM-enabled project in terms of collaboration and project value. The knowledge of justifying the success of BIM projects will help to identify whether a particular project is in the right track or not.
- The facts identified in the research, i.e. the source of knowledge will help both academic and practitioners to understand the trend of the adoption of BIM within the construction industry. For example, the activities and the relationships found can be used to initial idea to carry further research in terms of working environment in the BIM-enabled projects. At the same time, practitioners can find some evident information form this research that will help them to design the implementation of BIM in various projects. For instance, they can make a value planning to make sure everyone’s interest is secured, and this will help the PBO to achieve an improved and collaborative project delivery process.
- The cultural values defined in this research can be basic ideas to carry out further research. For example, if the programme Digital Built Britain is considered, it also has a strategic plan about culture. Findings from this study can be a source of ideas to take necessary actions in terms of attaining the desired culture.

- The methodology has been adopted in this research can provide a primary guideline for the researchers in the construction industry to design research methodology and carry out research work.
- Finally, people can have an idea about the cultural empathy, and desired interactions in a common data environment in the BIM-enabled projects, which is explained in the different items such as components and outcomes of BIM.

CHAPTER 7: DISCUSSIONS AND CONCLUSIONS

7.1 Overview

This chapter mainly focuses on discussions and conclusions of the findings. The overall discussion is concentrated on answering research questions based on the findings derived using different activities, i.e. data analysis of GT study, regression analysis, case study, and results from the CVF analysis across the investigated projects.

This study is envisioned to explore the implementation of BIM in the construction project delivery process and has identified the relationship between the culture of construction project-based organisations and the implementation of BIM. Further, the findings include the interactions that occur among the participants in a project while operating BIM. In addition, this study tracks a way of assessment of the success level of the implementation of BIM. The study also identifies the behavioural changes in the people working in the construction industry within a transition period of a cultural shift. During this period, the people in the construction industry are adopting a technology of new generation. Existing literature and practical context of the implementation of BIM suggest that the inherent phenomena of the BIM-enabled project are unconvincing on several issues. This study is intended to answer following two major research questions:

1) What is the relationship between the culture of a construction project-based organisation and the implementation of BIM?
2) What are the interactions that take place among the participants in a construction project while operating BIM?

7.2 What is the Relationship between the Culture of a Construction Project-Based Organisation and the Implementation of BIM?

In a BIM project, as a temporary setting, it has been found that the organisational culture is developed through several aspects such as the working arrangements, participation in project works through modelling, and technology-driven interactions between the parties. The overall feature of the culture in a BIM project has been drawn in this study is as viewed by Deal and Kennedy (1982) as ‘the way we do things around here’. It means the entire phenomena of the project delivery process where diverse disciplines work together for the common goal. This includes the people, the integral process, and necessary technology used to carry out the projects. Cultural elements in various projects were investigated on the basis of the research context which is extracted from different sources, such as CVF, regression analysis, correlation test, extant literature, and words of respondents came through the GT study. The trend in the construction project-based organisations in terms of culture and the operation of BIM are as follows:

Leadership is a vital factor to design the implementation of BIM and has influence on the integral parts of BIM

In this study, it is found that the leader in a BIM project means that the identifiable person who is involved in the initial phase of the project, and designs both the implementation of BIM for the whole lifecycle of the project and execution of the project. A desired leader in a BIM project is the knowledgeable person who understands the particular elements of BIM. These are the inherent value of BIM, the process of information modelling, managing information, necessary skills to carry out modelling process in a particular project, and the tools to support the overall project delivery process. Actions of a project leader influence various parts of the implementation of BIM which in turn impact the outcomes of a project in terms of BIM. The elements of BIM which are influenced by a project leader are:

- BIM implementation plan and protocol
- Data exchanges and accessibilities
- Value optimisation
- Capacity building programme.

These integral parts of the implementation of BIM are the internal factors which in turn dictate the work process, behaviour of the people during collaboration, and benefits to be extracted through the implementation of BIM.

The internal factors of BIM influence the outcomes in a project

The internal factors in a BIM project are the determinants for the outcomes in a BIM project. The outcomes in a BIM project which have been found influenced by internal factors are:

- Coordination and integration
- Value added to the project
- Interactions between the parties.

Relationships between these factors and the outcomes of the implementation of BIM are underpinned by the process of BIM. Apparently, successful implementation of BIM drives the behaviour and working style of the people in construction project-based organisations. The nature of the influence of the internal factors on the outcomes of the implementation of BIM has been described below:

- Factors such as *BIM implementation plan and protocol, Data exchanges and accessibilities, Value optimisation,* and *Capacity building programme* individually influence *the interactions between the parties* at a significant level. While all of these are present, at least one of the variables has impact on the level of interactions happen between the participants, i.e. value optimisation. Value optimisation in a project encourages the interactions between the parties at any condition either individually or simultaneously with other factors. This indicates that people do come forward when they can see their own interests.
- *Data exchanges and accessibilities* and *value optimisation* simultaneously influence the *value level of BIM* (value added through the implementation of BIM) in a project. The participation of the people in the modelling process is encouraged by the value proposition for both individuals and the team. When individuals find their interests within the common process that is functioning in the project, achieving project goal (to improve the project delivery process and add value in the project) is stimulated through the individual goals.
- *Coordination and integration* in a BIM project is significantly influenced by the articulated *value optimisation*. Through the value optimisation, the scope of adding value within the whole lifecycle of a project is identified for all the stakeholders in a supply chain. Identification of value in various aspects drives individual parties to

achieve both individual and project goals. For instance, an improvement in information management (i.e. adding value through the process) where individual have accesses, can exchange information and save time individually on each event. This facility in consecutively enables seamless information flow and functionalises collaboration among the parties. This way of coordination saves time and minimises the difficulties and complexities in both design coordination and physical execution of the project.

Based on the above three relationships, this study establishes that the factor value optimisation influences all three outcomes (coordination and integration, value level of BIM, and interactions between the parties) in a BIM project in any condition such as individually or simultaneously. Additionally, in the study, it has been found that value optimisation in a project fosters the success of the implementation of BIM. Therefore, value optimisation is a critical determinant of the successful implementation of BIM in construction projects.

Individual organisational cultures have influence on the culture of BIM-enabled project-based organisations but the cultural differences are minimised by the implementation of BIM

The culture of individual organisations in a construction project influence the way of working in a BIM-enabled project by various aspects such as individuals' work setting, existing financial or technical capabilities, level of understandings, organisational objectives, and intention to invest on new technology. However, it has been found that when BIM is adopted in a project, the impacts of cultural differences are minimised by the implementation of BIM through number of activities. These are:

- Developing the project specific implementation plan
- Clear objectives
- Achievable and foreseeable value proposition
- Agreement on selected tools, standards and process of desired coordination and integration
- Necessary supports from the lead organisations to motivate the individuals to participate in technology-driven process.

Implementation of BIM builds the culture of the construction project-based organisations

It has been found that the implementation of BIM drives a cultural shift in the construction project-based organisations. When BIM is adopted in a project, it provides a new shape of the project delivery process through fundamental changes in following elements:

- Behaviour of the people in terms of coordination and integration—driven by *people*;
- Information management—driven by modern *technology*;
- Project delivery process—driven by new *process* of both coordination and execution.

Findings of this research (from GT, Correlation test, Regression analysis, and CVF analysis) establish that the culture of any of the organisations involved in a particular project does not necessarily dominate the type of the culture of a project-based organisation. Also, there is no particular culture that drives the success of the implementation of BIM. A successful implementation of BIM can build any kind of culture in a project. In a word, the hybrid culture of a BIM-enabled project-based organisation is shaped by the implementation of BIM.

7.3 What are the Interactions that Take Place among the Participants in a Construction Project While Operating BIM?

It has been seen that the interactions between the parties take place in a BIM-enabled project are the model driven interactions. These model-driven interactions are functionalised through the participation of the people in various activities in a BIM project. When BIM is implemented in a project, a common data environment is developed with a defined open communication channel. Various functional parties interact between each other when they carry out various activities underpinned by the process of BIM. These are:

- Multi-disciplinary coordination and collaboration
- Coordination within individual work zone defined in the model
- Model interactions to detect clashes
- Visualisation of pragmatic issues in the model
- Data coordination for offsite manufacturing
- Rehearsals for construction procedure
- Regular model review, face to face meeting, and personal interactions:
- Problem solving through the model

- Accessing the common data environment and providing annotation in the model for particular issues
- Online meetings with screen share.

People from diverse disciplines in a BIM project participating in these activities share knowledge through the interactions take place among them. It has been seen that when different disciplines intend to work in a single zone, they perform clash detections and construction rehearsals. Related people observe and understand the works of other parties in a zone where they are intending to work. In this way, relevant parties can exchange their ideas to depict the best condition of work in a particular zone.

It has been found that when model interactions are performed or pragmatic issues are visualised at the presence of people from diverse disciplines, the issues raised on a particular item become visible to them. Discussions are made between each other in a more transparent way. As the problem is visualised in the 3D model, people understand what the real issues are. Individual parties accept the necessary actions to be undertaken by them rather than blaming each other. In this way, cultural empathy is improved between the parties through the model driven interactions. Eventually, model driven interactions encourage the people to work in a collaborative way in a BIM-enabled project.

7.4 Conclusion

The implementation of BIM offers both adding value to the project and improvement of the project delivery process by embracing new approach of work. The integral parts of the process of adopting BIM influence the value to be added in a project and shape the culture within a project-based organisation. The desired culture in a BIM project is attracted by the value proposition of BIM for the individual parties if it is realistic and persuasive. Thus, the implementation of BIM not only permits the value to be complemented in a project but also shapes the culture of a project-based organisation.

7.5 Limitations of the Study

This study was undertaken among the construction projects which are in the construction phase. Human related issues were primary focus in the study rather than technical issues.

This study was carried out within BIM-enabled construction projects to understand the culture of project-based organisations and the entire method of the implementation of BIM taking place within the construction industry. According to the GT approach, some of the concepts were addressed only until those were addressed or discussed by the following respondents. Therefore, discussions had been made on certain entities in the findings which might not be satisfactorily connected with the existing literature.

In this study, during the verbal conversations, respondents expressed their ideology and personal opinion based on the implementation of BIM taking place within the project delivery process they are directly connected. People expressed their conceptions and described the meanings in accordance with their position and certain existing conditions such as working practice of individual organisations, the project specific implementation plan, work volume, deliverables, the supply chain, and IT facilities. Therefore, it might be yet convincing that any of the respondents who expressed a notion and his intended actions in a changing environment might have stated the other contemporary things if only they were provoked in other way during the interview.

This study is focused on the adoption of new generation of technology in the construction industry. The varieties of software packages are available in the market and the numbers of upcoming software are increasing day by day as the vendors are attempting to grab the growing market as much as they can. Diversity in practice and opinion exist among the respondents depending on their existing process and available tools to carry out the modelling process. Therefore, many of the particular activities which are related to the specific tools may not be feasible to interpret with other related activities in general.

Implementation of BIM is new to the industry and the available literature related to the culture of BIM-enabled PBO is still limited. The environment is changing with time and the volume of upcoming literature is growing. Consequently, it may be still persuasive that further critical discussions could be made if only the related literature was available in hand.

7.6 Empirical Implications

The findings have relied mostly on the words of the respondents where they have gone through a changing environment with distinctive project settings. The theoretical associations of the findings therefore need to be reconsidered in order to make an attempt for further understanding on the culture of project-based organisations and the implementation of BIM.

Existing literature suggests that BIM is being implemented within the construction industry, for example, in the UK, with a strategic target undertaken by the government which does not necessarily clarify the overall industrial needs (Garvey, 2015). However, this study suggests that the strategic plan of implementing BIM in individual projects are done in certain way that meets the vision of the individual organisations as well as the government strategy of various countries (Hossain and Munns, 2015).

The findings of this research propose that the operation of BIM allows easier coordination and quick decision making throughout the whole lifecycle of the project for instance in the phases of planning, design, operation, and construction. This part of findings is consistent with the thought provided by number of authors (Hardin, 2009; Gu and London, 2010; Parn et al., 2015b). Furthermore, the overall findings extend the insight on various issues such as information management, coordination activities, actions of a leader in a BIM project, value proposition, capacity building of the participants and behaviour of the people within CDE to cope up with the leading-edge technology.

Execution of BIM is driven by the implementation plan with the application of particular settings in terms of technology. Moreover, this influences the various cultural elements of the project-based organisations that contradicts with the thought of stable economic organisational culture presented by Cameron and Quinn (2011). The reason of the contradiction may be reinforced by the process of modelling emphasized by technology and the temporary organisational setting of project-based organisation which differs from the stable economic organisations.

7.7 Methodological Implications

This study was carried out with adopting hermeneutic phenomenology through GT approach and triangulation in terms of both methodological and data triangulations. Though GT approach is widely used in the qualitative research, next to the constructivist linear approach of the methodology, the adopted approach in this study the data collection and analysis guided by GT. The study enabled a sound understanding on the adoption process of hermeneutic phenomenology and GT. Conducting the study performs a smooth continuous process of collecting and analysing data throughout the further investigation The validation of the findings from the investigation including the applied approach were followed by publication of results though different dissemination activities (Hossain *et al.*, 2013; Hossain and Munns, 2015).

During the study, the emerged concepts were endeavoured to refine and explore in the further interviews. Through this process, the connections between the concepts and the cultural elements of the project-based organisations within the project delivery process driven by BIM were identified. This testifies the faithful approach along with the credibility and originality. Categories were gradually sharpened and inundated throughout the interviews with the related people from diverse background in various projects. Successively, the saturation and sharpening the categories have proved the achievement of resonance and usefulness of the systematic approach which is highly recommended by Charmaz (2006).

Triangulation in methodology and data aspects reinforced and strengthened the claims derived through the GT approach. A validation of qualitative study has been performed by using other two other methodologies. These kinds of multiple triangulations can provide better understanding on attesting obtained results from a qualitative research.

The investigation was carried out in particular settings in a changing environment. The findings are consistent with some of the contemporary thoughts. The inherent thoughts, actions, and process of the people within the construction industry became apparent through the study. Thus, the adoption of hermeneutic phenomenology appears as one of the effective ways to investigate the way of life in particular setting such as construction project-based organisations.

7.8 Practical Implications

The findings of this study recommend that the process of implementation of BIM can be in different ways such as focusing on government mandate, organisational vision, and the capability of individual organisations. In a range of BIM-enabled projects, the overall picture of the fundamental parts of the project management has become apparent. This will provide an idea on setting up a BIM implementation plan for particular projects in terms of information management, selection of appropriate tools, desired behaviour of the people within CDE, necessity of capacity building, collaboration, coordination, people-process-technology integration, and rethinking the overall construction project delivery process.

The connections found between the integral parts of BIM and the outcomes of a project in terms of BIM will provide an idea on the impacts of various activities of BIM on the outcomes in a project.

Understanding the effects of the implementation of BIM and the organisational culture on each other will enhance the level empathy, tolerance, and acceptance on the consequence of the application of latest technology among the people within the industry. In turn, the understanding on the considerable impacts of the implementation of BIM will help to ease coordination and integration process in a more transparent way.

The findings in terms of interactions between the parties give a clear perception of the behaviour of the people in a technology-driven environment. Thus, a party can identify desired behaviour from other parties and address the deliverables accordingly. The calibration of the value level of BIM can be used to measure the extent of value added in the project beyond meeting the government's strategic target.

7.9 Recommendations for Future Research

After discussing the empirical, methodological, and practical implications along with the limitations, following recommendations have been drawn for the future research:

- This research dealt with the categories in connection with CVF and the notions from the GT study. As such, certain items, for example, types or styles of leadership in a BIM project, can be studied in future by considering wide range of relevant literature.
- This study includes the BIM-enabled projects in the UK, Ireland, Brazil, China, France, and Canada; and the non BIM projects are in Australia and UK. Since the purposes of the implementation of BIM in the UK are different from the purposes of BIM in other countries (i.e. functionalising effective coordination and winning projects), further studies can be carried out at wider level to focus on creating value through the application of leading-edge technology.

- There are some projects which are fully and partly client-driven. Investigations can be carried out separately to draw the clearer pictures in both cases. This will enable to understand the sharing of knowledge between the parties.
- A number of tools will be increasingly available with time. People in the industry will have better understanding on the subject. This will guide their future actions within the project delivery process underpinned by technology. Findings from this research can be used as the starting point of further investigation to identify new concepts and relevant phenomena in current or upcoming projects, or the projects after the transition period of the cultural move.
- Future study can be carried out in a wide range based on the integral parts of BIM and the relationships identified in this study.

REFERENCES

Abeysekara, V. & Lata, P. 2002. Understanding 'Culture' in an International Construction Context *In:* Unknown, ed. First International Conference on Construction in the 21st Century- "Challenges and Opportunities in Management and Technology", 25-27 April 2002 Miami, USA. CITC, 327-334.

AEC-UK. 2012. AEC (UK) BIM Protocol-Project BIM Execution Plan. *Implementaion of UK BIM Standards for the Architectural, Engineering and Construction Industry* [Online]. Available: https://aecuk.files.wordpress.com/2012/09/aecukbimprotocol-bimexecutionplan-v2-0.pdf [Accessed 03-08-2015].

Agger, B. 1991. Critical Theory, Poststrucralism, Postmodernism: Their Sociologocal Relevance. *Annual Reviews:: Sociology,* 17(N/A)**,** 105-117.

Ahmad, A. M., Demian, P. & Price, A. D. F. 2012. BIM Implementation Plans: A Comparative Analysis. *In:* Smith, S. D., ed. 28th Annual ARCOM Conference, 3-5 September 2012 Edinburgh, UK. ARCOM, 33-42.

AIA 2007a. *A Working Definition: Integrated Project Delivery,* California, AIA california Council.

AIA 2007b. *Integrated Project Delivery: A Guide,* California, AIA California Council.

Ajjawi, R. & Higgs, J. 2007. Using Hermeneutic Phenomenology to Investigate How Experienced Practitioners Learn to Communicate Clinical Reasoning. *The Qualitative Report,* 12(4)**,** 612-638.

Akintoye, A., McIntosh, G. & Fitzerald, E. 2000. A survey of Supply Chain Collaboration and Management in the UK Construction Industry. *European Journal of Purchasing & Supply Management,* 6(2000)**,** 159-168.

Alas, R., Ubius, U. & Gaal, M. A. 2012. Predicting innovation Climate using the Competing Values Model *Social and Behavioral Sciences* 62(2012)**,** 540-544.

Ancarani, A., Mauro, C. D. & Giammanco, M. D. 2009. How are organisational climate models and patient satisfaction related? A competing value framework approach. *Social Science and Medicine,* 69(2009)**,** 1813-1818.

Andre, G. R. 2011. Building Information Modeling (BIM): Special Contract Issues. Available: http://www.klconstructionlawblog.com/2011/10/articles/articles-and-publications/building-information-modeling-bim-special-contract-issues/ [Accessed 09-05-2012].

Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C. & O'Reilly, K. 2011. BIM Adoption and Implementation for Architectural Practices. *Structural Survey,* 29(1)**,** 7-25.

Arayici, Y., Egbu, C. & Coates, P. 2012. Building Information Modelling (BIM) Implementation and Remote Construction Projects: Issues, Challeneges and Critiques. *Journal of Information Technology in Construction,* 17(2012)**,** 75-92.

Ashcraft, H. W. 2008. Implementing BIM: A Report from the Field on Issues and Strategies.

Autodesk. 2015. BIM - Get Started. *Solutions-Building Information Modelling* [Online]. Available: http://www.autodesk.co.uk/solutions/building-information-modeling/overview/get-started [Accessed 03-08-2015].

Azhar, S., Hein, M. & Sketo, B. 2011. Building Information Modeling (BIM): Benefits, Risks, and Challenges for the AEC Industry *Leadership Management in Engineering, ASCE,* 11(3)**,** 241-252.

Back, W. E. & Macdonald, R. 2012. An Organizational Approach to Leadership Development for Engineering and Construction Management Project Practitioners *International Journal of Business, Humanities and Technology,* 2(2)**,** 121-131.

Barima, O. K. B. 2010. Examination of the Best, Analogous, Competing Terms to Describe Value in Construction Projects. *International Journal of Project Management,* 28(2010)**,** 195-200.

Beal, V. 2016. Information Silo. Available: http://www.webopedia.com/TERM/I/information_silo.html [Accessed 09-01-2016].

Bernstein, P. G. & Pittman, J. H. 2004. Barriers to the Adoption of Building Information Modelling in the Building Industry. *White Paper* [Online].

Bew, M. & Underwood, J. 2009. Delivering BIM to the UK Market. *In:* Underwood, J. & Isigdag, U. (eds.) *Handbook of Research on Building Information Modelling and Construction Informatics: Concepts and Technologies.* New York: IGI-Global.

Birks, M. & Mills, E. J. 2010. *Grounded Theory: A pactical Guide,* London, Sage.

Blumer, H. 1980. Mead and Blumer: The Convergent Methodological Perspectives of Social Behaviourism and Social Interactionism. *American Social Review,* 45(3)**,** 409-419.

Bowen, D. A. 2006. Grounded Theory and Sensitizing Concepts. *International Journal of Qualitative Methods,* 5(3)**,** Unknown.

Bryant, A. 2002. Re-grounding Grounded Theory. *The Journal of Information Technology Theory and Application (JITTA),* 4(1)**,** 25-42.

Bryman, A. 2013. Triangulation and Measurement *Social Science* [Online]. Available: http://www.referenceworld.com/sage/socialscience/triangulation.pdf [Accessed 03-11-2015].

BSI 2010. Constructing the Business Case: Building Information Modelling. *In:* Institution, B. S. (ed.). London: British Standards Institution.

BSI 2013. *PAS 1192-2 Specification for Information Management for the Capital/Delivery Phase of Construction Projects Using Building Information Modelling*, BSI.

BSI 2014. *PAS 1192-3 Specification for Information Management for the Operational Phase of Assets using Building Information Modelling (BIM),* London, Building Specification for Information (BSI).

Buchanan, D. A. & Huszynski, A. A. 2010. *Organizational Behaviour*, Essex, Prentice Hall.

C2P2AI 2008. *Relational Contracting,* MichiganUniversity, M. S., Michigan State University.

Cain, C. T. 2003. *Building Down Barriers: A Guide to Construction Best Practice,* London, Spon Press.

Cameron, K. 2009. An Introduction to The Competing Values Framework. *Haworth Organizational Culture: White Paper* [Online]. Available: http://www.haworth.com/en-us/Knowledge/Workplace-Library/Documents/An%20Introduction%20to%20the%20Competing%20Values%20Framework.pdf [Accessed 02-06-2012].

Cameron, K. S. & Quinn, R. E. (eds.) 1999. Diagnosing and Changing Organizational Culture, USA: Addison-Wesley Series Publishing Company, Inc.

Cameron, K. S. & Quinn, R. E. 2006. *Diagnosing and Changing Organizational Culture*, San Francisco, Jossey-Bass.

Cameron, K. S. & Quinn, R. E. 2011. *Diagnosing and Changing Organizational Culture* San Francisco, Jossey-Bass.

Cameron, K. S., Quinn, R. E., DeGraff, J. & Thakor, A. V. 2006. Competing Values Leadership: Creating Value in Organizations.

Charmaz, K. 1983. The Grounded Theory Method: An Explication and Interpretation. *Theory and Evidence in Field Research,* Unknown(Uknown)**,** 109-127.

Charmaz, K. 2006. *Constructing Grounded Theory,* London, Sage.

Charmaz, K. 2008. *Constructionism and the Grounded Theory Method,* New York, The Guildford Press.

CIC. 2013. Building Information Model (BIM) Protocol. Available: file:///C:/Users/user/Downloads/the-bim-protocol%20(1).pdf [Accessed 10-10-2014].

Clough, R. H., A., S. G. & K., S. S. 2008. *Construction Project Management: A Practical Guide to Field Construction Management,* New Jersey, Wiley.

CO 2011. *Government Construction Strategy,* London, Cabinet Office (CO).

Cook, T. & Campbell, D. T. 1979. *Quasi-experimentation: Design and Analysis Issues for Field Settings,* Boston, Houghton Mifflin.

Corbin, J. & Strauss, A. 1990. Grounded Theory Research: Procedures, Canons, and Evaluative Criteria. *Qualitative Sociology,* 13(1)**,** 3-21.

Cousins, P. 2007. NEC3: What is all Fuss About? Available: http://www.ciarb.org/branches/great-britain/south-east/news-and-views/2008/january/nec3-what-is-all-the-fuss-about [Accessed 12-10-2012].

Creswell, J. W. 2007. *Qualitative Inquiry and Research Design: Choosing Among Five Approaches,* London, Sage.

Crotty, M. 1998. *The Foundations of Social Research,* London, SAGE.

CTGR 2012. *Client Task Group Report*, London, Cabinet Office.

Dakhil, A. & Alshawi, M. 2015. BIM Cient Maturity: Literature Review. 12th International Post-Graduate Research Conference, 10th-12th June 2015 Manchester.

Davis, J., Millburn, P., Murphy, T. & Woodhouse, M. 1992. *Successful Team Building: How to Create Teams that Really Work,* London, Kogan Page.

Deal, T. E. & Kennedy, A. A. 1982. *Organizational Culture: The Rites and Rituals of Organization Life,* Reading, MA: Addson Wesley.

Denzin, K. N. & Lincoln, Y. S. (eds.) 2005. The Discipline and Practice of Qualitative Research, *The sage Handbook of Qualitative Research Denzin, K. N. & Lincoln, Y. S.,* London: Sage.

Dickson, V. S., James, E. L., Kippen, S. & Liamputtong, P. 2007. Doing sensitive research: what challenges do qualitative researcher face? *Qualitative Research,* 7(3)**,** 327-353.

Dossick, C. S. & Neff, G. 2010. Messy Talk and Clean Technology: Requirements for Inter-organizational Collaboration and BIM Implementation within the AEC Industry. *In:* Taylor, J. E. & Chinowsky, P. (eds.) *Engineering Project Organizations Conference.* South Lake Tahoe: EPOS.

Dunn, M. 2016. JCT Contracts "An Overview". Available: https://www.architecture.com/RIBA/Assets/Files/Part3docs/April/Spring%20Lecture%20Notes%20UK/JCTcontractoverview-MichaelDunn.pdf [Accessed 04-01-2016].

Eastman, C. M., Eastman, C., Teicholz, P., Sacks, R. & Liston, K. 2011. *BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers and Contractors,* Canada, John Wiley and Sons.

Egan, J. 1998. *Rethinking Construction,* LondonForce, T. C. T., Construction Task Force.

Egan, J. 2002. *Accelerating Change,* LondonConstruction, S. F., Strategic Forum for Construction.

Elmualim, A. A. 2008. Moral Leadership Education in Construction. *In:* Dainty, A., ed. 24th Annual ARCOM Conference, 2008 Cardiff, UK. Association of Researchers in Construction Management, 393-402.

Fan, Y. 2000. A Classification of Chinese Culture. *Cross Cultural Management,* 7(2)**,** 3-10.

Faraway, J. J. 1999. *Practical Regression and Anova, Using R,* Unknown, Unknown.

Fernie, S., Leiringer, R. & Thorpe, T. 2006. Change in Construction: A Critical Perspective. *Building Research and Information,* 34 (2)(2)**,** 91-103.

Fleming, Q. W. & Koppelman, J. L. 1996. Integrated Project Development Teams: Another fad... or a Permanent Change. *International Journal of Project Management,* 14(3)**,** 163-168.

Fong, P. S. W. & Lung, B. W. C. 2007. Interorganizational Teamwork in the Construction Industry. *Journal of Construction Engineering and Management @ ASCE,* 133(2)**,** 157-168.

Fossey, E., Harvey, C., McDermott, F. & Davidson, L. 2002. Understanding and Evaluating Qualitative Research. *Conducting Research in Psychiatry,* 36(6)**,** 717-732.

Garvey, R. 2015. Has the UK Government Strategy Delivered. 12th International Post-Graduate Research Conference, 10th to 12th June 2015 Manchester.

Glaser, B. G. 1978. *Theoretical Sensitivity,* Mill Valley, CA, Sociology Press.

Glaser, B. G. & Strauss, A. L. 1967. *The Discovery of Grounded Theory,* London, AldineTransactions.

Glick, S. & Guggemos, A. A. 2009. IPD and BIM: Benefits and Opportunities for Regulatory Agencies. Available: http://ascpro0.ascweb.org/archives/cd/2009/paper/CPGT172002009.pdf [Accessed 20-07-2012].

Grendstad, G. & Strand, T. 1999. Organizational Types and Leadership Roles. *Scandinavian Journal of Management,* 15(1999)**,** 385-403.

Groenewald, T. 2004. A Phenomenological Research Design Illustrated. *International Jounal of Qualitative Methods,* 3(1)**,** 1-26.

Gu, N. & London, K. 2010. Understanding and Facilitating BIM adoption in the AEC Industry. *Automation in Construction*, 19(2010)**,** 988-999.
Gu, N., Singh, V., London, K., Lijiljana & Taylor, C. 2008. BIM : Expectations and a Reality Check. *In:* Unknown, ed. 12th International Conference on Information Technology in Construction, 2008 Beijing, China. QUT Digital Repository.
Guba, E. G. (ed.) 1990. The Alternative Paradigm Dialog, *The Paradigm Dialog Guba, E. G.*, London: SAGE.
Guba, E. G. & Lincoln, Y. S. (eds.) 1994. Competing Paradigms in Qualitative Research, *Handbook of Qualitative Research Denzin, K. N. & Lincoln, Y. S.*, London: Sage
Guba, E. G. & Lincoln, Y. S. (eds.) 2011. Paradimatric Controversies, Contradictions, and Emerging Confluences, *Denzin, K. N. & Guba, E. G.*, London: Sage.
Guion, L. A. 2002. *Triangulation: Establishishing the Validity of Qualitative Studies*, Florida, University of Florida Extension.
Gunduz, H. B. 2008. An Evaluation of Belbin's Team Roles Theory (The Case of Anatolian Profession High School, profession High School, and Vocational High School for Industry). *World Applied Sciences Journal*, 4(3)**,** 460-469.
Hancock, B. 1998. *An Introduction to Qualitative Research*, Notingham, Trent Focus.
Hardin, B. 2009. *BIM and Construction Management*, Indiana, Wiley.
Harvey, S., Bruce, M. & Smith, D. 1998. Developing Successful Teams in Organisations. *Australian Journal of Management & Organisational Behaviour*, 1(1)**,** 1-8.
Hathaway, R. S. 1995. Assumptions Underlying Quantitative and Qualitative Research. *Research in Hogher Education*, 36(5)**,** 535-562.
Hauke, J. & Kossowski, T. 2011. Comparison of Values of Pearson's And Spearman's Correlation Coefficients on the Same Sets of Data. *Quaestiones Geographicae* 30(2)**,** 87–93.
Heath, H. & Cowley, S. 2004. Developing a grounded theory approach: a comparison of Glaser and Strauss. *International Journal of Nursing Studies*, 41(2004)**,** 141-150.
Helfrich, C., D., Li, Y. F., Mohr, D. C., Meterko, M. & Sales, A. E. 2007. Assessing an organizational culture instrument based on the Competing Values Framework: Exploratory and confirmatory factor analyses. 2. Available: http://www.implementationscience.com/content/2/1/13 [Accessed 12-05-2013].
Hersey, P. & Blanchard, K. H. 1993. *Management of Organizational Behavior: Utilizing Human Resources*, Englewood Cliffs, Prentice Hall.
Hoebel, A. 1960. *Man, Culture and Society*, New York, Oxford University Press.
Hofstede, G. 1980. *Cultures' Consequences*, London, Sage Publications.
Hofstede, G. 2001. *Cultures' Consequences*, London, Sage.
Holroyd, C. 2001. Phenomenological Research Method, Design and Procedure: A Phenomenological Investigation of the Phenomenon of Being-in-Community as Experienced by Two Individuals Who Have Participated in a Community Building Workshop. *Indo-Pacific Journal of Phenomenology*, 1(1)**,** 1-10.
Holroyd, C., Currie, L. & Wooten, G. F. 2001. Prospective Study of Hallucinations and Delusions in Parkinson's Disease. *J Neurol Neurosurg Psychiatry*, 70(N/A)**,** 734-738.
Holtzhausen, S. 2001. Triangulation as a Powerful Tool to Strengthen the Qualitative Research Design: The Resource-based Learning Career Preparation Programme (RBLCPP) as a Case Study. *Qualitative Research on Educatinal Development* [Online]. Available: http://www.leeds.ac.uk/educol/documents/00001759.htm [Accessed 12-10-2014].
Hossain, M. K. & Munns, A. 2015. Digital Engineering: A Case Study on the Implementation of Building Information Modelling (BIM) in the Construction Projects. 12th International Post-Graduate Research Confeence, 10th-12th June 2015 Manchester.
Hossain, M. K., Munns, A. & Rahman, M. 2013. Enhancing Team Integration in Building Information Modelling Projects. *In:* Boyd, D., ed. BIM: Management and Interoperability, 20th June 2013 Birmingham. Birmingham City University.

Hussein, M. E., Hirst, S., Salyers, V. & Osuji, J. 2014. Using Grounded Theory as a Mehtod of Inquiry: Advantages and Disadvantages. *The Qualitative Report* [Online], 19. Available: http://www.nova.edu/ssss/QR/QR19/el-hussein13.pdf [Accessed 25/01/2015].

Husserl, E. (ed.) 1983. Ideas Pertaining to a Pure Phenomenology and to a Phenomenological Philosophy, *Edmund Husserl Kersten, F.*, Boston: Kluwer.

ICE. 2016. Simon Report. Available: http://www.designingbuildings.co.uk/wiki/Simon_Report [Accessed 06-01-2016].

Ilozor, B. D. & Kelly, D. J. 2012. Building Information Modeling and Integrated Project Delivery in the Commercial Construction Industry: A Conceptual Study. *Engineering, Project, and Production Management,* 2(1)**,** 23-36.

Jackson, P. R. 2000. Interdependence as a Key Requirement for Successful Introduction of Teamworking: A case Study. *In:* Procter, S. & Muller, F. (eds.) *Teamworking.* London: Macmillan Business.

Jick, T. D. 1979. Mixing Qualitative and Quantitave Methods: Triangulation in Action. *Administrative Science Society,* 24(December)**,** 602-611.

Jones, M. & Alony, I. 2011. Guiding the Use of Grounded Theory in Doctoral Studies - An Example from the Australian Film Industry. *International Journal of Doctoral Studies,* 6(N/A)**,** 95-114.

Kafle, N. P. 2011. Hermeneutic Research Method Simplified. *Bodhi: An Interdisciplinary Journal,* 5(Unknown)**,** 181-200.

Kakkori, L. 2009. Hermeneutics and Phenomenology Problems When Applying Hermeneutic Phenomenological Methods in Educational Qualitative Research. *Paideusis,* 18(2)**,** 19-27.

Karau, S. J. & Williams, K. D. 1993. Social Loafing: A Meta-Analytic Review and Theoretical Integration. *Journal of Personality and Social Psychology,* 65(4)**,** 681-706.

Kasapoğlu, E. 2011. Leadership Behaviors in Project Design Offices. *American Society of Civil Engineers,* 137(5)**,** 356-363.

Khalfan, M. M. A. & McDermott, P. 2007. Integrated Supply Chain–An Example from the UK Construction Industry. *The construction and building research conference of the Royal Institution of Chartered Surveyors.* Georgia Tech, Atlanta: RICS.

Khiat, H. 2010. A grounded Theory Approach: Conceptions of Understanding in Engineering Mathematics Learning. *The Qualitative Report,* 15(6)**,** 1459-1488.

Khosrowshahi, F. & Arayici, Y. 2012. Roadmap for Implementation of BIM in the UK Construction Industry. *Engineering, Construction, and Architechtural Management,* 19(6)**,** 610-635.

Kincheloe, J. L. & P.L., M. (eds.) 2000. Rethinking Critical Theory and Qualitative Research, *Handbook of Qualitative Research Denzin, K. N. & Lincoln, Y. S.,* Thousand Oaks, CA: Sage.

Kreitner, R. & Cassidy, C. 2012. *Management,* Massachusetts, Houghton Mifflin.

Latham, M. 1994. *Constructing the Team,* LondonHer Majesty's Stationery Office.

Laverty, S. M. 2003. Hermeneutic Phenomenology and Phenomenology: A comparison of Historical and Methodological Considerations. *International Jounal of Qualitative Methods,* 2(3)**,** 21-35.

Lester, S. 1999. An Introduction to Phenomenological Research. *Stan Lester Developments*.

Lock, M. 2012. *Data Management for BI: Big Data, Bigger Insight, Superior Performance,* UKInc., A. G., Aberdeen Group.

Losemore, M. 1999. Cultural Sensitivity in Methodological Design. *Construction, Management and Economics,* 17(5)**,** 553-561.

MacKinnon, G. 2005. Symbolic Interactionism: A lens for Judging the Social Constructivist Potential Learner Centred Chemistry Software. *International Journal of Technology in Teaching,* 1(2)**,** 89-102.

Macmillan, S. 2011. *Effective Teamwork – A Good Practice Guide for the Construction Industry,* London, Construction Research & Best Practice.

Madison, G. B. 1988. *The Hermeneutics of Postmodernity: Fugures and Themes,* Indianapolis, Indiana University Press.

Malleson, A. 2012. *BIM Survey: Summary of findings,* LondonNbs.

Manen, M. V. 2007. Phenomenology of Practices. *Phenomenology & Practice,* 2007(1)**,** 11-30.

Markus, H. R. & Kitayama, S. 1991. Culture and the Self: Implications for Cognition, Emotion, and Motivation. *Psychological Review,* 98(2)**,** 224-253.

Marshall, C. & Rossman, G. 1999. *Designing Qualitative Research,* New York, SAGE.

Mauthner, N. S. & Daucet, A. 2003. *Sociology,* Taxas, Sage.

McAdam, B. 2010. The UK Legal Context for Building Information Modelling. CIB World Building Congress, 10-13 May 2010 Salford. CIB.

Mickan, S. & Rodger, S. 2000. Characteristics of Effective Teams: A Literature Review. *Australian Health Review,* 23(3)**,** 201-208.

Minitab. 2015. How to Interpret Regression Analysis Results: P-values and Coefficients. Available: http://blog.minitab.com/blog/adventures-in-statistics/how-to-interpret-regression-analysis-results-p-values-and-coefficients [Accessed 01-02-2015].

Moran, D. 2000. *An Introduction to Phenomenology,* London, Routledge.

Morris, P. W. G. & Huge, G. H. (eds.) 1986. Preconditions of Success and Failure in Major Projects, *The Management of Projects College, T.,* Kinnington Oxford: The Oxford Centre for Mangament Studies.

Mosey, D. 2005. PPC2000 Briefing Note.

Mullins, J. L. 2010. *Management and Organisational Behaviour,* Essex, Pearson Education Limited.

Munns, A. & Bjeirmi, B. F. 1996. The Role of Project Management in Achieving Project Success. *International Journal of Project Management,* 14(2)**,** 81-87.

Mustafa, R. F. 2011. The P.O.E.Ms Educational Research: A Beginners' Concise Guide. *International Education Studies,* 4(3)**,** 23-30.

BIM Scotland, 2011. Youtube. Directed by NBS. Scotland.

NBS. 2014a. BIM Levels Explained. *Building Information Modelling* [Online]. Available: http://www.thenbs.com/topics/bim/articles/bim-levels-explained.asp [Accessed 02-12-2014].

NBS 2014b. *NBS National BIM Report 2014,* Riba, RIBA.

Newton, S. 2008. Changing the framework for leadership in the construction industry. *In:* Dainty, A., ed. 24th Annual ARCOM Conference, 1-3 September 2008 Cardiff, UK. Association of Researchers in Construction Management, 433-442.

Nooy, W. D. 2009. Formalising Symbolic Interactionism. *Methodological Innovations Online,* 4(2009)**,** 39-52.

Parker, G. M. 2007. *Team Players and Teamwork,* San Fransico, Jossey Bass A Wiley Inprint.

Parn, E., Colombage, L. & Thurairajah, N. 2015. Affordances of BIM During the Architectural Design Process. *International Post-Graduate Research Conference.* Manchester, UK.

Pascale, C. M. 2011. *Cartographies of Knowledge,* London, Sage.

Patton, M. Q. 1990. *Qualitative Evaluation and Research Methods,* London, SAGE.

Pell, A. R. 2010. *The Complete Idiot's Guide to Team Building,* Alfa Books.

Philp, D. 2012. BIM and the UK Construction Strategy. *Building Information Modelling* [Online]. Available: http://www.thenbs.com/topics/bim/articles/bimAndTheUKConstructionStrategy.asp [Accessed 05-07-2012].

Polkinghorne, D. (ed.) 1983. Phenomenological Research Methods, *Existential-Phenomenologiocal Perspective in Psychology Valle, R. S. & Halling, S.,* New York: Springer US.

Ponterotto, J. G. 2005. Qualitative Research in Counseling Psychology: A Primer on Research Paradigms and Philosophy of Science. *Journal of Counseling Psychology,* 52(2)**,** 126-136.

Popper, K. 1959. *The Logic of Scientific Discovery,* London, Routledge.

Porwal, A. & Hewage, k. n. 2013. Building Information Modeling (BIM) partnering framework for Public Construction Projects. *Automation in Construction,* 31(2013)**,** 204-214.

Quinn, R. E. & Rohrbaugh, J. 1983. A Spatial Model of Effectiveness Criteria: Towards a Competing Values Approach to Organizational Analysis. *Management Science,* 29(3)**,** 363-377.

Rawlings, J. O., Pantula, S. G. & Dickey, D. A. 1998. *Applied Regression Analysis: A Research Tool,* New York, Springer.

Redmond, A., Hore, A., Alshawi, M. & West, R. 2012. Exploring how Information Exchanges can be Enhanced through Cloud BIM. *Automation in Construction,* 24(2012)**,** 175-183.

Rich, P. 2012. Inside the Black Box: Revealing the Process in Applying a Grounded Theory Analysis *The Qualitative Report,* 17(49)**,** 1-23.

Rickards, T. & Moger, S. 2000. Creative Leadership Processes in Project Team Development: An Alternative to Tuckman's Stage Model. *British Journal of Management,* 11(2000)**,** 273-283.

Robbins, S. P. 2003. *Organizational Behavior,* New Jersey, Prentice Hall.

Roma, T. Y. & Ogunlana, S. O. (eds.) 2009. Culture and Workplace Behavior: A Case Study of Joint Venture Construction Projects in Thailand, *Joint Ventures in Construction Kobayashi, K., Khairuddin, K. R., Ofori, G. & Ogunlana, S. O.,* London: Thomas Telford.

Rosenberg, L. T. 2007. Building Information Modeling. *Partnering for Success* [Online].

Rush, F. (ed.) 2004. Conceptual Foundations of Critical Theory*, The Bambridge Companion of Critical Theory Rush, E.*, Cambridge: Cambridge University Press.

Russom, P. 2013. *Managing Big Data,* Tdwi, TDWI Research.

Sbaraini, A., Carter, S. M., Evans, R. W. & Blinkhorn, A. 2011. How to do a GroundedTtheory Study: A Worked Example of a Study of Dental Practices. *BMC Medical Research Methodology,* 11(128).

Schwandt, T. A. (ed.) 1994. Constrctivist, Interpretivist Approaches to Human Inquiry*, Handbook of Qualitative Research Denzin, K. N. & Lincoln, Y. S.,* London: Sage.

Sciarra, D. (ed.) 1999. The Role of the Qualitiative Researcher*, Using Qualitative Methods in Psychology Kopala, M. & Suzuki, L. A.,* Thousand Oaks, CA: Sage.

SDLR 2007. *A380 South Devon Link Road Major Scheme Business Case,* Devon, Devon County Council

Searle, J. R. 1995. *The Construction of Social Reality,* London, Penguin Books.

Sebastian, R. 2010. Breaking Through Business and Legal Barriers of Open Collaborative Processes Based on Building Information Modelling (BIM). CIM World Building Congress, 2010 Salford. CIB, 166-186.

Sheng, C. W., Tian, Y. F. & Chen, M. C. 2010. Relationship Among Teamwork Behaviour, Trust, Perceived Team Support, and Team Commitment. *Social Behaviour and Personality,* 38(10)**,** 1297-1306.

Snape, D. & Spencer, L. (eds.) 2003. The Foundations of Qualitative Research*, Qualitative Research Practice Lewis, J. & Ritchie, J.,* London: Sage.

Solomon, M. R. 1983. The Role of Products as Social Stimuli: A Symbolic Interactionism Perspective. *Journal of Consumer Research,* 10(3)**,** 319-329.

Steele, J. L. & Murray, M. A. P. 2001. 'Constructing the Team' – A Multi-cultural Experience. *In:* Cibse, ed. Chartered Institute of Building Services Engineers – National Conference 2001, 2001 London. London: CIBSE.

Strauss, A. & Corbin, J. (eds.) 1993. Grounded Theory Methodology*, Strategies of Inquiry Unknown*.

Strauss, A. & Corbin, J. 1998. *Basics of Qualitative Research Techniques and Procedures for Developing Grounded Theory,* London, Sage Publications.

Succar, B. 2009. Building Information Modelling framework: A Research and Delivery Foundation for Industry Stakeholders. *Automation in Construction,* 18(3)**,** 357-375.

Sun, S. 2008. Organisational Culture and Its Themes. *International Journal of Business and Management,* 3(12)**,** 137-141.

Tarricone, P. & Luca, J. 2002. Successful teamwork: A case study. 25th HERDSA Annual Conference, 7-10 July 2002 Perth, Western Australia. Higher Education Research and Development Society of Australasia, Inc., 640-646.

Thompson, M., Ellis, R. & Wildavsky, A. 1990. *Cultural Theory,* Oxford, Westview Press.

Toor, S. U. R. & Ogunlana, S. O. 2007. Critical COMs of Success in Large-scale Construction Projects: Evidence from Thailand Construction Industry. *International Journal of Project Management,* 26(2008)**,** 420-430.

Tyson, L. 2006. *Critical Theory Today,* London, Routledge.

Udom, K. 2012. BIM: Mapping out the Legal Issues. *Building Information Modelling* [Online]. Available: http://www.thenbs.com/topics/bim/articles/bimMappingOutTheLegalIssues.asp [Accessed 07-09-2012].

Underwood, J. & Isigdag, U. 2009. *Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies,* New York, IGI-Global.

Underwood, J. & Khosrowshahi, F. 2012. ICT Expenditure and Trends in the UK Construction Industry in Facing the Challenges of the Global Economic Crisis. *Journal of Information Technology in Construction,* 17(2012)**,** 26-41.

Walker, B. L. & Walker, D. 2011. Authentic Leadership for 21st Century Project Delivery. *International Journal of Project Management,* 29(2011)**,** 383-395.

Walker, D. 2011. Grounded Theory: An Exploration of Process and Procedure. *Qualitative Research,* 16(4)**,** 547-559.

Webspace. 2016. Pearson's Correlation. Available: http://webspace.ship.edu/pgmarr/Geo441/Lectures/Lec%2010%20-%20Pearsons%20Correlation.pdf [Accessed 12-01-2016].

Wickersham, J. 2009. Legal and Business Implications of Building Information Modeling (BIM) and Integrated Project Delivery (IPD). *Rocket: BIM-IPD legal and business issues* [Online]. Available: http://isites.harvard.edu/fs/docs/icb.topic552698.files/Wickersham%20BIM-IPD%20legal%20and%20business%20isssues.pdf [Accessed 10-11-2012].

Wiewiora, A., Trigunarsya, B., Murphy, G. & Coffey, V. 2010. Organizational culture and willingness to share knowledge: A Competing Values Perspective in Australian Context. *International Journal of Project Management,* Unknown(Unknown)**,** Unknown (Published in 2013).

Wilcke, M. M. 2006. Hermeneutic Phenomenology as a Research Method in Social Work. *Currents: New Scholarships in the Human Services,* 1(1)**,** 1-10.

Williums, A., Dobson, P. & Watters, M. 1989. *Changing Culture,* London, Institute of Personnel Management.

Woodman, R. W. & Sherwood, J. J. 1980. The Role of Team Development in Organizational Effectiveness: A Critical Review. *Phsychological Bulletin,* 88(1)**,** 166-186.

Yan, H. & Demian, P. 2008. Benefits and Barriers of Building Information Modelling Available: http://www.staff.lboro.ac.uk/~cvpd2/PDFs/294_Benefits%20and%20Barriers%20of%20Building%20Information%20Modelling.pdf [Accessed 25-01- 2012].

Yun, S., Cox, J., Sims, H. P. J. & Salam, S. 2007. Leadership and Teamwork: The Effects of Leadership and Job Satisfaction on Team Citizenship *International Journal of Leadership Studies,* 2(3)**,** 171-193.

Appendix A

Results from CVF Analysis

Followings are the CVF analysis based on the data found in various projects:

Project P01-HW

Table 1: CVF scores in project P01-HW

Organisation	Score on cultures			
	Clan (A)	Adhocracy (B)	Market (C)	Hierarchy (D)
Project P01HW	29.67	12.33	24.0	34.0
Lead contractor	20.28	33.06	21.94	24.72
Subcontractor-C	31.67	17.92	20.42	26.67

CVF plotting for the subcontractor in the project P01-HW is shown below:

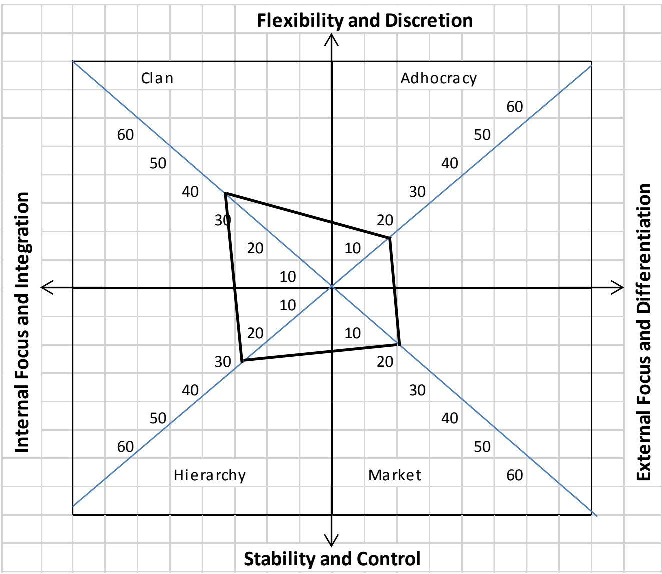

Figure 1: CVF *plotting* for a subcontractor in the project P01-HW

CVF plotting for the lead contractor of P01-HW is shown below-

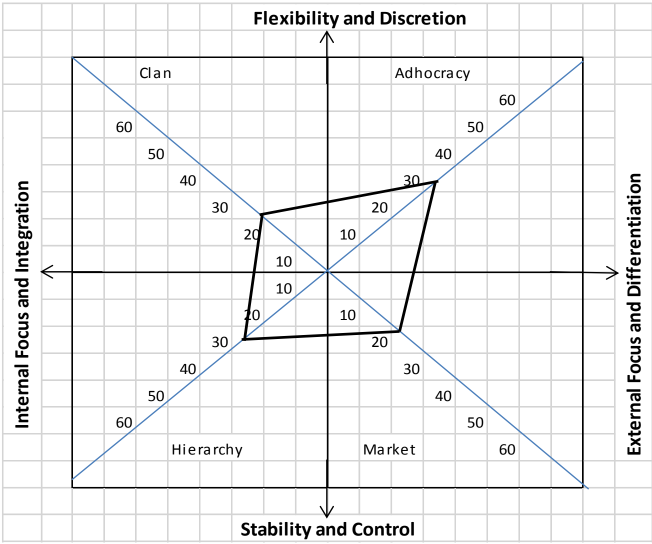

Figure 2: CVF plotting for the lead contractor in the project P01-HW

CVF for the culture of the project-based organisation (PBO) P01-HW-

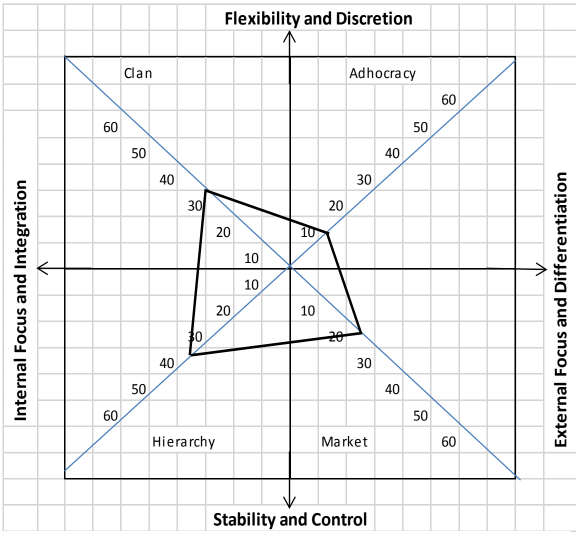

Figure 3: CVF plotting for the project-based organisation P01-HW

Plotting of the culture found in project P01-HW, Subcontractor, and Lead contractor-

Organisation	A	B	C	D
CVF Project P01-HW	29.667	12.33	24	34
Lead contractor	20.77	30.056	21.94	24.72
Subcontractor	31.67	17.92	20.41	26.67

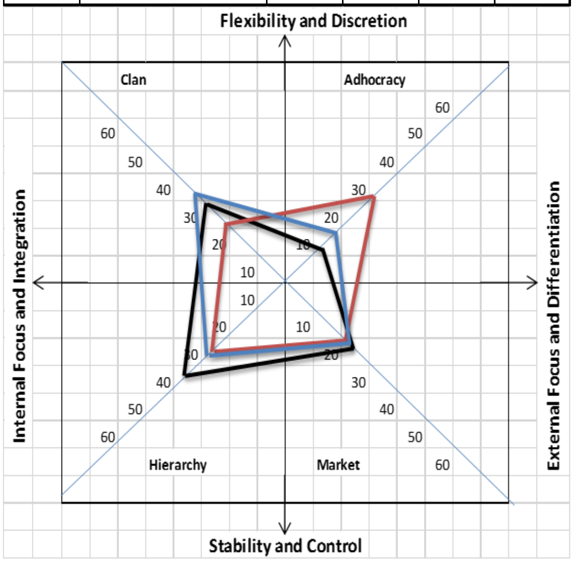

Figure 4: The various cultures in project P01-HW.

Project P02-HA

The CVF of Subcontractor has been found as follows:

CFV scores in the project P02-HA

Organisation	Score on cultures			
	Clan (A)	Adhocracy (B)	Market (C)	Hierarchy (D)
Project P02-HA	40	21.25	26.46	37.29
Lead contractor	20	33.33	28.33	18.3
Subcontractor-C	51.67	21.67	15	11.67
Consultant S	20.83	15.83	25	38.33
Consultant A	56.67	11.67	13.33	18.33

CVF for the lead organisation (contractor):

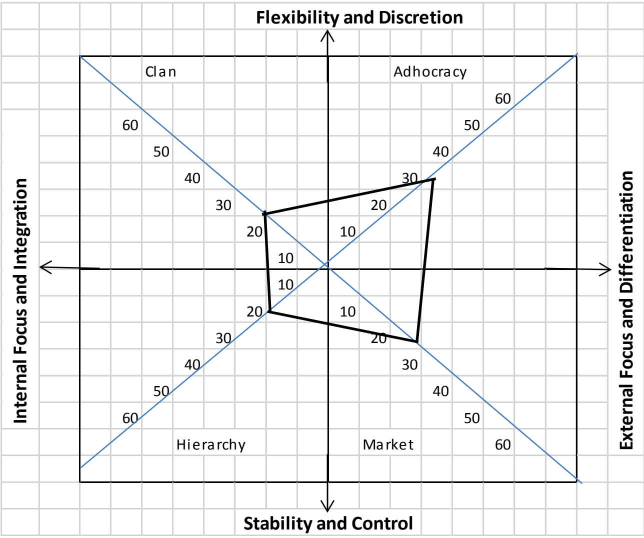

Figure 5: CVF plotting of the culture of the lead organisation in the project P02-HA

CVF plotting for the project-based organisation P02-HA:

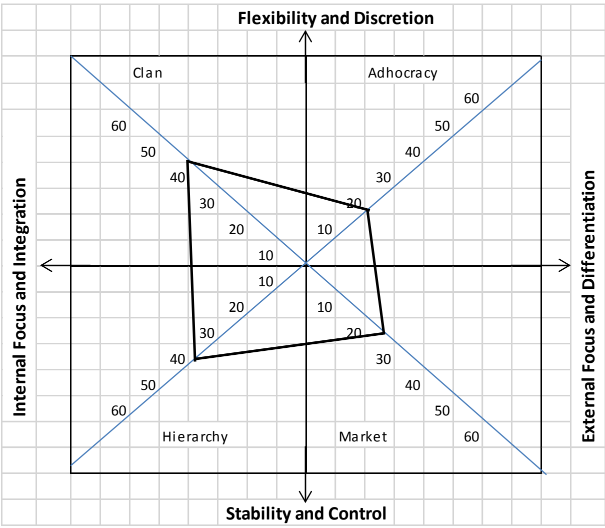

Figure 6: CVF plotting of the culture of the project-based organisation P02-HA

CVF for the Structural consultant in project P02-HA:

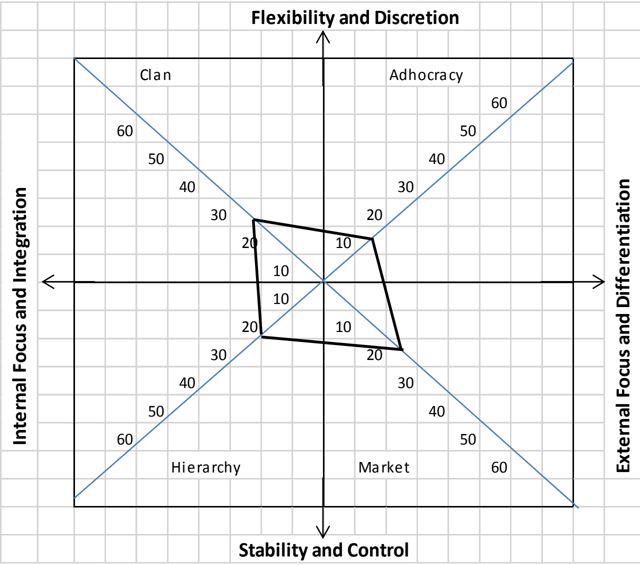

Figure 7: CFV plotting of the culture of the structural consultant in project P02-HA

CVF for the M&E subcontractor in project P02-HA:

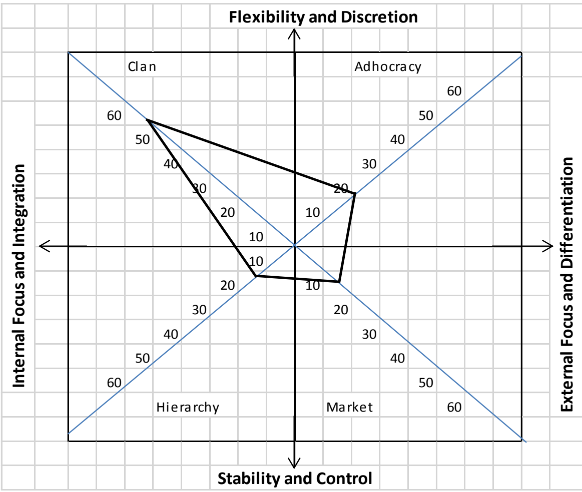

Figure 8: CVF Plotting of the culture of the subcontractor (M&E) in project P02-HA

CVF for the architectural consultant in project P02-HA:

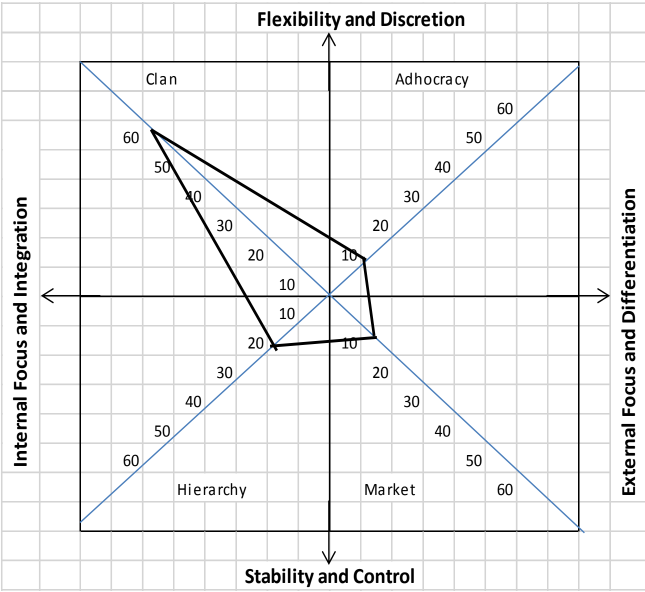

Figure 9: CVF plotting of the culture of the architectural consultant (Consultant A) in the project

The combined plotting of CVF for various organisations in project P02-HA and the PBO:

	Orgnaisation	A	B	C	D
	CVF Subcontractor M&E	51.67	21.67	15	11.67
	CVF Consultant S	20.83	15.83	25	38.33
	CVF Lead contractor	20	33.33	28.33	18.33
	CVF Consultant A	56.67	11.67	13.33	18.33
	CVF Project	40	21.25	26.45	37.29

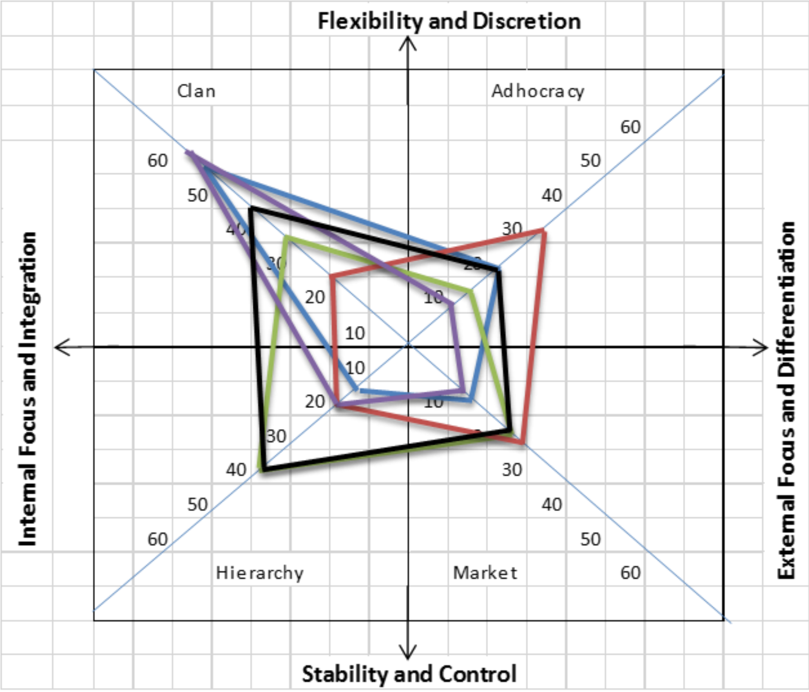

Figure 10: Combined CVF plotting of all the cultures in the project P02-HA

Appendix B

Key Quotes from the participants

Participants	Quotes	Category
P01-RKT	…the project leader operates a successful implementation (of BIM) there is everybody's interest in.	CT-03
P05-RZY	The people who don't know BIM, they think we are the enemy	CT-16, 17
P01-RPH	What he does, he makes sure that people understand, what they need to know, and that's driven into, and that's up to us today up and down the line… what we would say, leadership things.	CT-03
P01-RAF	He is very knowledgeable guy, he is always tuned into what is going on.	CT-03
P01-RAF	In terms of the overall project, he is always present there, and the information passed on we have got... So, he deals a quite a lot in terms of any client's changes or client issues, so they always getting coordinated through those meetings.	CT-03, 16, 17
P01-RSK	I have got champions… For the subcontractors we have got room for improvement. The subcontractors that we employ aren't there (level-2 BIM) yet.	CT-03
P04-RMT	The project leader still focuses on his job as keen as. They don't know about the BIM process they can do yet	CT-03
P04-RMT	I am not the project manager or design manager myself, I don't know the internal strategy they are working. It is trying to find what the end result to them, what they want from BIM process.	CT-03,16, 17
P10-RAD	I am the project leader… BIM is a contractual requirement and have been since tender. Our tender says we actually have; say, yes we are fully BIM-enabled project.	CT-03
P10-RAD	We actually BIM implement in our project; and we won the tender on our quality submission.	CT-03
P10-RSK	So, we have got quite a regimented structure of how we set our stall out… a lot less dynamic.	CT-16, 17
P10-RSK	I am wanting tighter level of control, I did not want dying with responsibilities.	CT-03, 17
P10-RDM	He is very result driven, and motivated. So he is quite used to using a process, and I am trying to get changing his way of thinking to a different process, is a little bit harder, but you can say that we can achieve the results.	CT-03
P01-RSC	What we did one is we set up a BIM protocol, how everybody work on file or information, so could all be brought together in a collaborative format, what would we work, what document management system we would use collate that, and how will we view and report against the model which is been developed… that is in our BIM protocol right to get in. We set that everybody had to use Navisworks; everybody had to use Revit 2009 and 2010.	CT-08
P03-RNW	The information management procedure we following are to the government standard that is PAS-1192. We are taking part-2 approach not the part-3.	CT-04, 08

Participants	Quote	Category
P04-RMT	You know trying to get information flow, and when the information is been produced as well. Because a lot of guys and a lot of designers are, we do still build of 2D drawings	CT-08
P03-RNW	We gonna apply at nearest down at PAS-1192; no matter the size of the project. If we do have project which is so small, they feel they don't need to touch this. But what we are trying to do is current common behaviour through the business and with our relationships, that's PAS-1192. If we can achieve doing that I think, the languages we share and the process we share will become common practice; and therefore, embedded and don't need to further that as much.	CT-04, 07, 17,
P05-RZY	This project is like an experiment.	CT-07, 43
P05-RZY	We have the project from AutoCAD, we also have the project make the drawings from Revit	CT-43
P08-RJH	We will do Navisworks and clash detection … we actually have to pass that model to the facilities management. …but that's fully documentary in Revit and we produce data drop security to produce facility management report	CT- 04, 07,43
P02-RDGM	you got the design team involves and working in certain way, the model should be used, not the drawings, then you can demonstrate the value of the model and the way through, all described in the model	CT-07, 43
P01-RAF	We are trying to integrate the model as much as we can, and if we have any coordination issues on site, we generally open up the BIM model, so that our peers can communicate around the BIM model itself.	CT-07, 17, 43
P01-RAF	…every week our document control are just asked to press the button and update any changes that are been made to all of our subcontractors' model. So, within that main model you will have your CM value…we also have separate entity models, can separately be saved and then within the middle of that.	CT-04, 07
P10-RPH	There is completely open access and that is completely open book. So our client sees what we are spending. We don't need to hide anything, and we have a good relationship with our client.	CT-04
P11-RSM	Actually between us we just exchange through the server….in our office we have one model where everyone can access. We have one file for trade and we link this file with the trader to create one common model. We print views from this model for the people who cannot have directly see from the model can see views from the models.	CT-04
P03-RNW	The modelling and information model point of view which hasn't set yet.	CT-04, 17
P03-RNW	They haven't realised that holistic cover that goes into their operational requirements, for the business that goes match into the client's operational requirements on the supply chain.	CT-04, 43
P01-RAF	We are trying to allow them to come in, so we are trying to spread the word a bit because if we learn now how to do it this the trying to get them to learn along with us.	CT-09
P08-RJH	I am also teaching staff, how to use Revit, this is actually a first Revit project in Glasgow.	CT-09
P02-RGC	So, we really are taking BIM taking on kind of boards and group discussions.	CT-17

Participants	Quote	Category
P02-RAR	We mentioned earlier with our objectives in terms of what we are to the end and buy-in and embed-in people from different objectives within everybody's appraisal system means that they are now on the way to do that.	CT-17
P09-RAG	We use the model. We have a plan, plan to work, logistics planning, breakdown areas in terms of design coordination and clash detection, and cost take-off.	CT-07, 17,
P09-RAG	I don't think it worth any commercial success	CT-07, 17, 45
P09-RAG	I think for us the success of the project will be we have sufficient staff members coming out the back end of the project, they are happy to use it. We would think it will automatically go to the next project and obtain benefit, I think that will be our success. I don't think we can really measure apart from, I don't think it worth any commercial success. We really apply on a project to get of it ready familiar with it".	CT-07, 17, 45
P06-RAC	In this industry there is nothing rather than face to face contact, talking things through, as long as right people in the right room, you can go on and have a look on the issues.	CT- 16
P02-RGC	So, our BIM model goes to the production factory sort of concrete panels now at the site. The factory in workshop is kind of 'James Bond' they set. So it is fantastic process	CT-17
P01-RKT	They are working for the same company and work for the same organisation and the money at the end is going to the same pot	CT-17
P03-RNW	The bit that hasn't been organised and isn't done that I recommended which is 4D planning approach which could have been systematic site approach	CT-07, 08, 43
P04-RMT	No, unfortunately those still don't in the site or the companies, you know trying to get information flow, and when the information is been produced as well. Because a lot of guys and a lot of designers are, we do still build of 2D drawings; so, the end of the day, deliverable to us as a company	CT-07, 08, 43

Appendix C

Project Profiles in Brief

Sl. No.	Project	Value (£)	Type of project	BIM is Contractual or not	Location
01	P01-HW	£90 million	Hospital	Yes	UK
02	P02-HA	£288 million	Hospital	Yes	UK
03	P03-FA	£250 million	Flood alleviation	Yes	UK
04	P04-SS	£6.8 million	School	No	UK
05	P05-CC	£310 million	Business park	No	China
06	P06-WS	£ 2.17 billion	Water supply	Yes	Brazil
07	P07-TH	£70 million	Hotel	Not known	UK
08	P08-DM	Not known	Laboratory	Yes	UK
09	P09-SA	£65 million	Housing	No	UK
10	P10-AI	£15 million	Research hub	Yes	Ireland
11	P11-SF	Not known	Hotel	Yes	France
12	P12-HC	£2.1 billion	Hospital	Yes	Canada
13	P13-CBNB	£2 million	Shopping mall	N/A	UK
14	P14-SANB	£20 million	Hospital	N/A	Australia

Appendix D

3. Questions used in the interviews

This interview will be recorded with the permission of the respondent, and confidentiality will be maintained accordingly. All the questions will described during conversations. This is an open questionnaire to answer verbally.

Questions-

1. Please tell me briefly about your project where BIM is being implemented.
   a) Is BIM contractual in this project?
   b) How much the project budget is?
2. What is your role in this project?
   a) Beyond this project, what is your role in the company?
3. Can you briefly tell me what level of BIM is being implemented in this project now, as per Cabinet Office mandate?

4. Please tell me how the people from different organisations work together in this project as a team?
   b) Is this project-based organisation very dynamic? Are the people willing to take risks here? How is that?
   c) Are the people from different organisations seen as competing nature rather than doing teamwork?
   d) Is this project-based virtual organisation very much controlled and strictly regulated to ensure smooth operation? Can you please tell me about this?

5. Please tell me briefly about the leader in this project and how he leads the project in terms of BIM?
   a) How the leader of this project makes decisions and takes actions? Does he consult or take other participants' opinion before making any decision?
   b) Do you think the leader has a significant role in the implementation of BIM? How is that?
   c) How the leader of this project helps the people who are new to BIM or incapable to cope up with the process?
   d) Is the leader interested to undertake capacity building programme?

6. Can you please tell me how the team members communicate with each other and solve the problems?
7. What is the basic strategy that the management of this project follow, such as competition, marketing, or teamwork?

a) What level the organisation emphasises on mutual trust, openness, new ideas/opportunities, and target achievement?

8. Do the project management use any specific evaluation process for the different parties working in the project?
   a) How do you feel about the existing system of evaluating criteria of the success of individuals and organisational success here?
   b) Do you think any other options that might be better for this project?

9. How do the contract parties exchange the documents for this project while operating BIM?
   a) Thinking back of earlier times, what were the means of exchanging documents in this type of project in absence of BIM?
   b) Considering different exchange modes such as email, common data environment or paper based whatever, which one you think to be the effective? Can you please tell me something about this?

10. What kind meetings are held in this project?
    a) How frequently the meetings are held?
    b) Are the decisions made by accounting the opinions of the participants in the meetings?
    c) Is the decision making process significantly different from a conventional construction project without BIM?

11. Are you aware of IPD that is implemented in the large construction projects for multi-party contracting?
    a) Do you think the implementation of BIM follows the principles of IPD?
    b) How do you feel the similarity and difference between IPD and BIM?

12. Does your organisation try to maintain a long-term relationship between the other organisations? Or it comes by contract?
    a) Can you give any example of things that have been done to help the team relationships between the people working in a single project?
    b) In your opinion what are the critical drivers behind maintaining relationship in this type of project, in your opinion?
    c) Do you think BIM embraces different parties in a long-term relationship? How is that?

13. Can you please tell me how the BIM is used in different phases of this project? What are the major BIM activities that you perform in this project?
    a) Did you have any interoperability or other technical issues yet?
    b) How do you evaluate the success of the implementation of BIM?
    c) Do you think the implementation of BIM has an impact on the traditional way of working in this type of construction projects? How significant the impact is?
    d) To produce same amount of information is it easier through BIM software than 2D CAD?
    e) What are the key drivers that make BIM successful?
    f) What are the key barriers that hinder implementation of BIM?

14. Can you please explain that how the culture of different organisations such as consultants, architects or subcontractors or clients influence the way BIM has been implemented on this project?

15. How is the whole project delivery process now after implementation of BIM, in terms of process fragmentation and information flow?
    a) How is the interaction between the participants been with BIM?
    b) Do the participants integrate with the core process of BIM smoothly? Does it require any extra effort from the management?
16. Do you think people make more communication between themselves in a BIM project?
17. In your opinion, what things can be done to implement BIM more successfully for this project?

Thank You